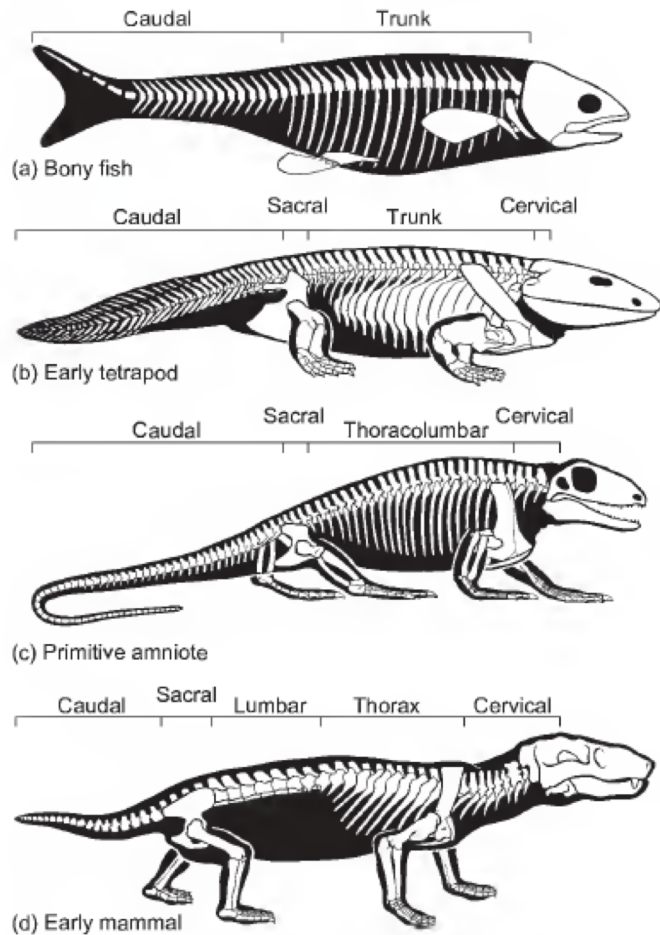
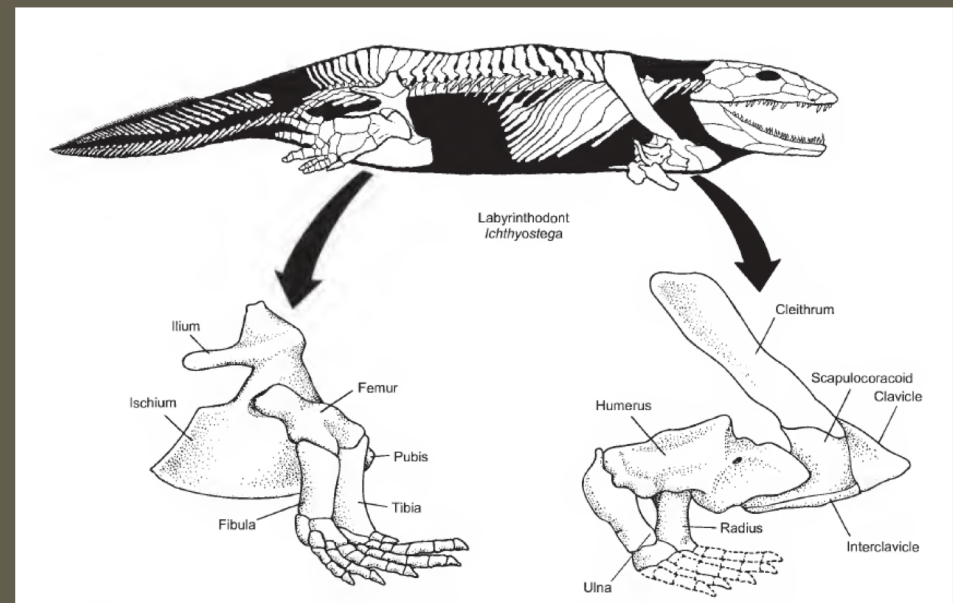
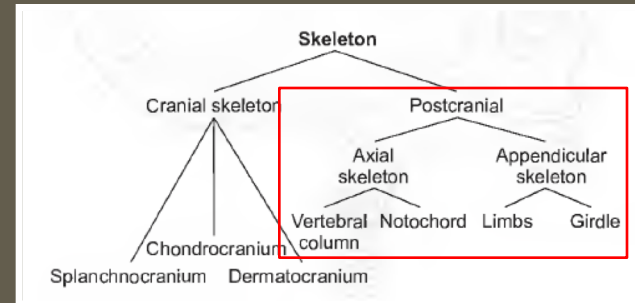


ESQUELETO

PARTE 2 = Esqueleto pós-craniano



1 - Esqueleto axial



2 - Esqueleto apendicular

Divisão do esqueleto

craniano e pós-craniano

Craniano

- 1) Neurocrânio
- 2) Esplancnocrânio (arcos maxilares, hióideos e branquiais)

Pós-craniano

- 1) Axial (coluna, notocorda, costelas, esterno, nadadeiras ímpares)
- 2) Apendicular (cinturas e membros peitorais e pélvicos)

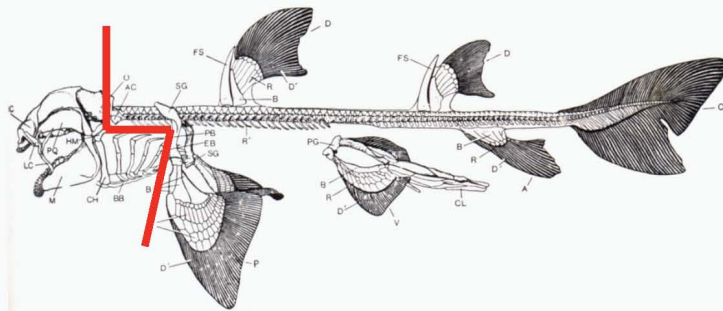
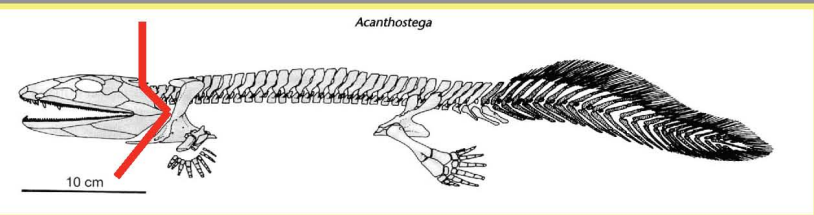


Fig. 107. Skeleton of a shark (Cestracion). *A*, Anal fin; *AC*, auditory capsule; *B*, basal elements of fin; *BB*, basibranchial; *C*, caudal fin; *CH*, ceratohyal; *CL*, claspers of male; *D*, dorsal fins; *D'*, dermal rays of fin; *EB*, epibranchial; *FS*, fin spines; *HM*, hyomandibular; *LC*, labial cartilages; *M*, mandible; *NC*, nasal capsule; *O*, orbit; *P*, pectoral fin; *PB*, pharyngobranchial; *PG*, pelvic girdle; *PQ*, palatoquadrate; *R*, radial elements of fin; *R'*, ribs; *SG*, pectoral girdle; *V*, pelvic (ventral) fin. (From Dean.)

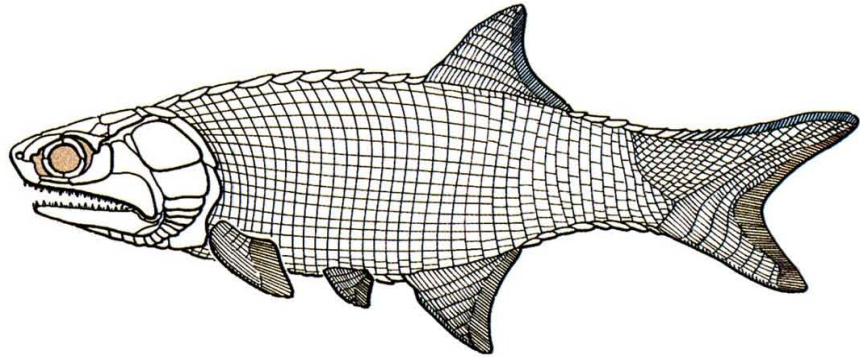
craniano

pós-craniano



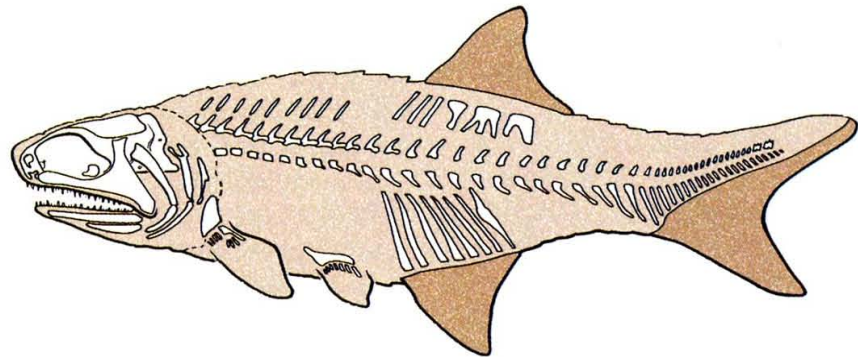
Osteichthyes

Esqueleto dérmico



Endoesqueleto

- ossificação endocondral



O esqueleto pós-craniano é de origem endocondral

Origem dos componentes do esqueleto Axial

esclerótomo

Mesoderma se divide em 3 somitos durante a neurulação:
1- esclerótomo
2- miótomo
3- dermátomo

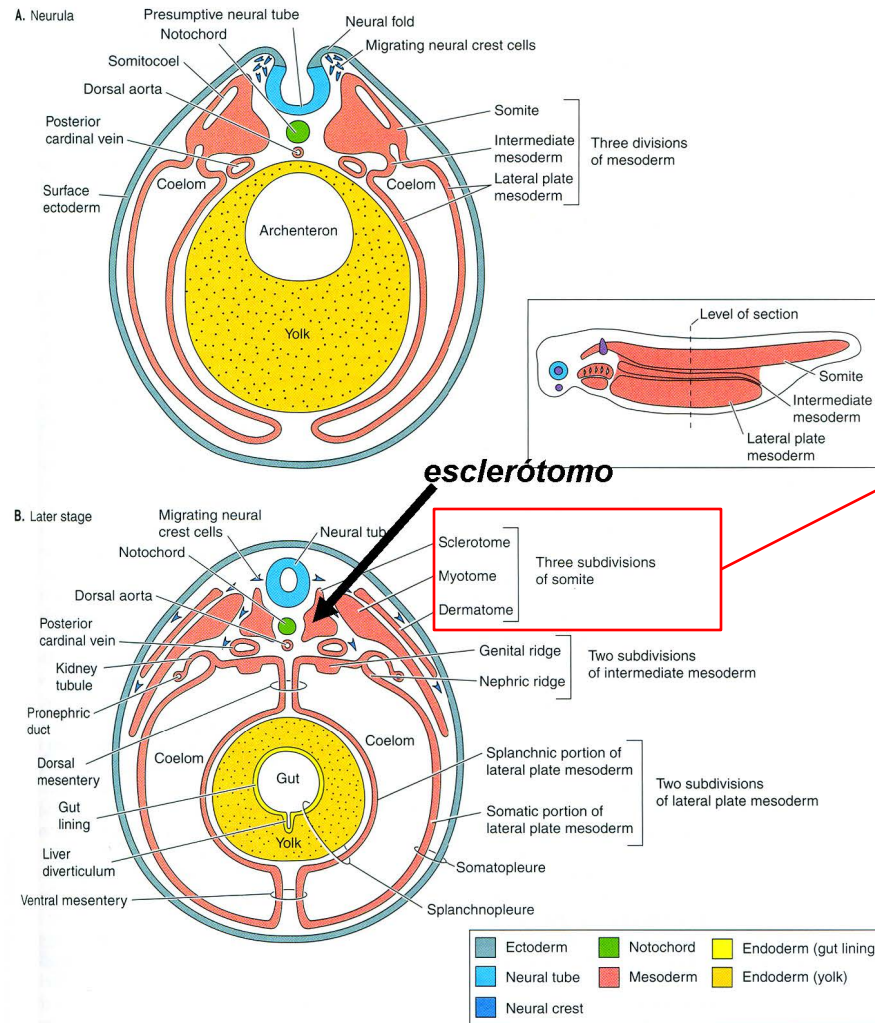


FIGURE 4-16

Differentiation of trunk mesoderm in an idealized amphibian embryo. A, Early neurula. The inset shows a lateral view and the plane of section for the figure in A. It also diagrams the basic organization of the three divisions of trunk mesoderm. In amphibian embryos (and other vertebrates with mesolecithal eggs) the moderate amount of yolk is incorporated into yolk-laden cells in the floor of the archenteron. B, Later neurula, showing the structures that develop from each somite and each germ layer. Note that each of the three divisions of trunk mesoderm diagrammed in A in turn gives rise to subdivisions. See text for additional descriptions.

Esqueleto tem uma origem mesodérmica através das células que se diferenciam a partir do esclerótomo

Origem dos componentes do esqueleto Axial

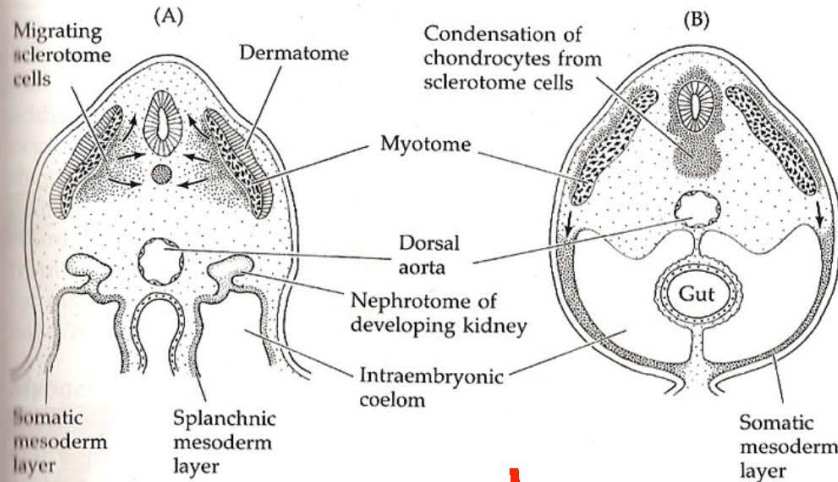
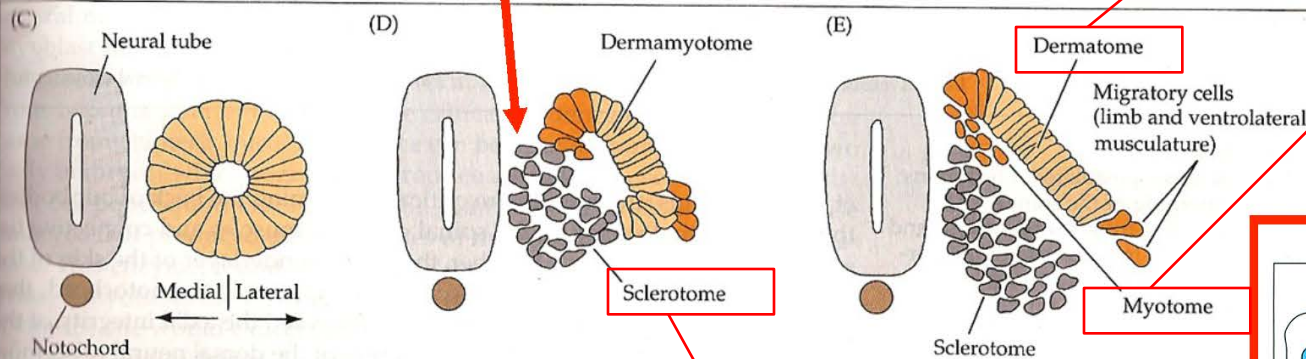


Figure 9.5

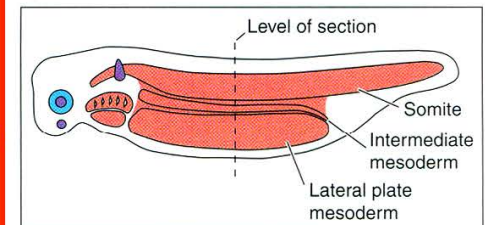
Diagram of a transverse section through the trunk of (A) an early 4-week and (B) a late 4-week human embryo, showing formation of somite structures. (A) The sclerotome cells are beginning to migrate away from the myotome and dermatome. (B) By the end of the fourth week, the sclerotome cells are condensing to form cartilaginous vertebrae, the dermatome is starting to form the dermis, and the myotome cells are extending ventrally down the walls of the embryo. (C-E) The changing structure of the chick somite as cell migrations occur. (A and B after Langman, 1981; C-E after Ordahl, 1993.)

Dermátomos = migram e condensam para formar a dermis

Miótomos = estendem e ventralmente para formar a musculatura vertebral e axial



Esclerótomos = migram para formar as vertebraas cartilaginosas



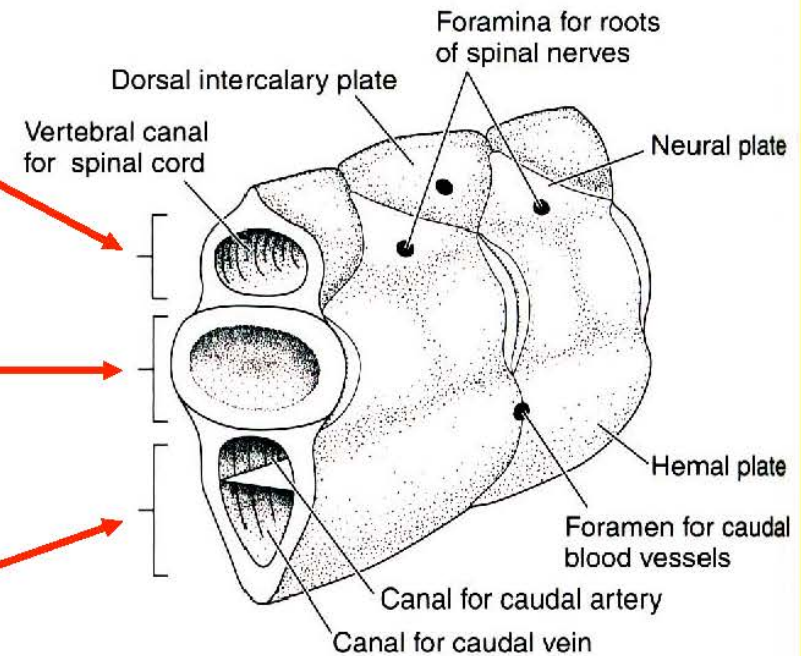
Esqueleto Axial

Estrutura das vértebras

arco neural: protege tubo nervoso, pode ter zigapófises

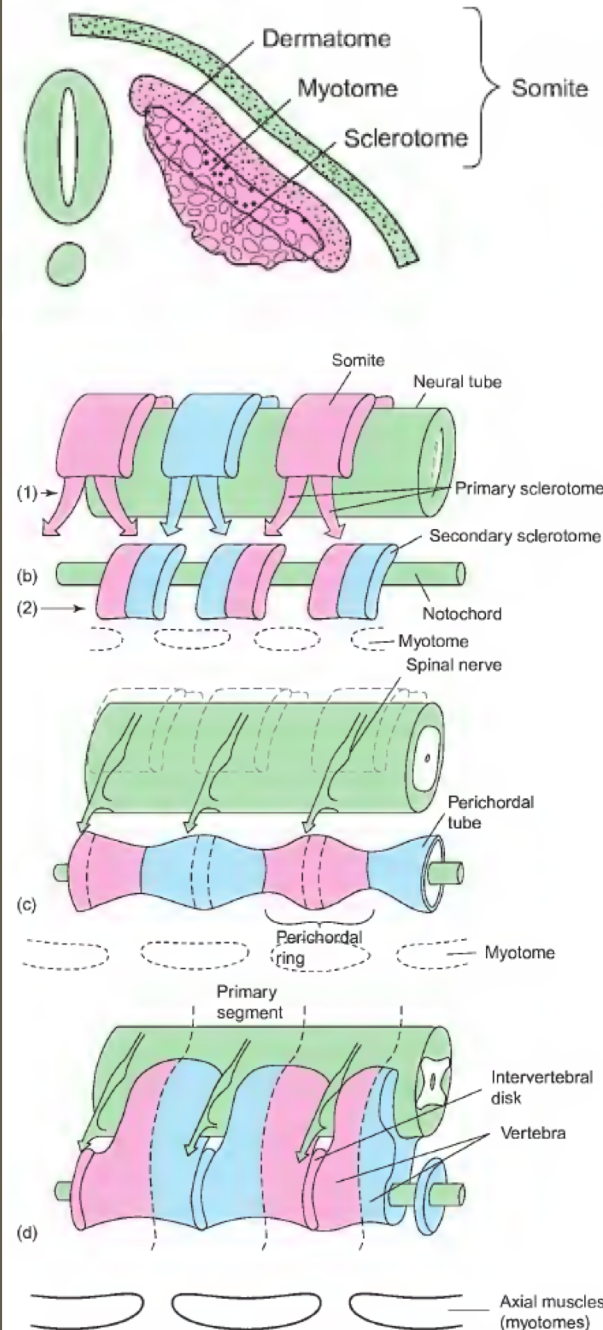
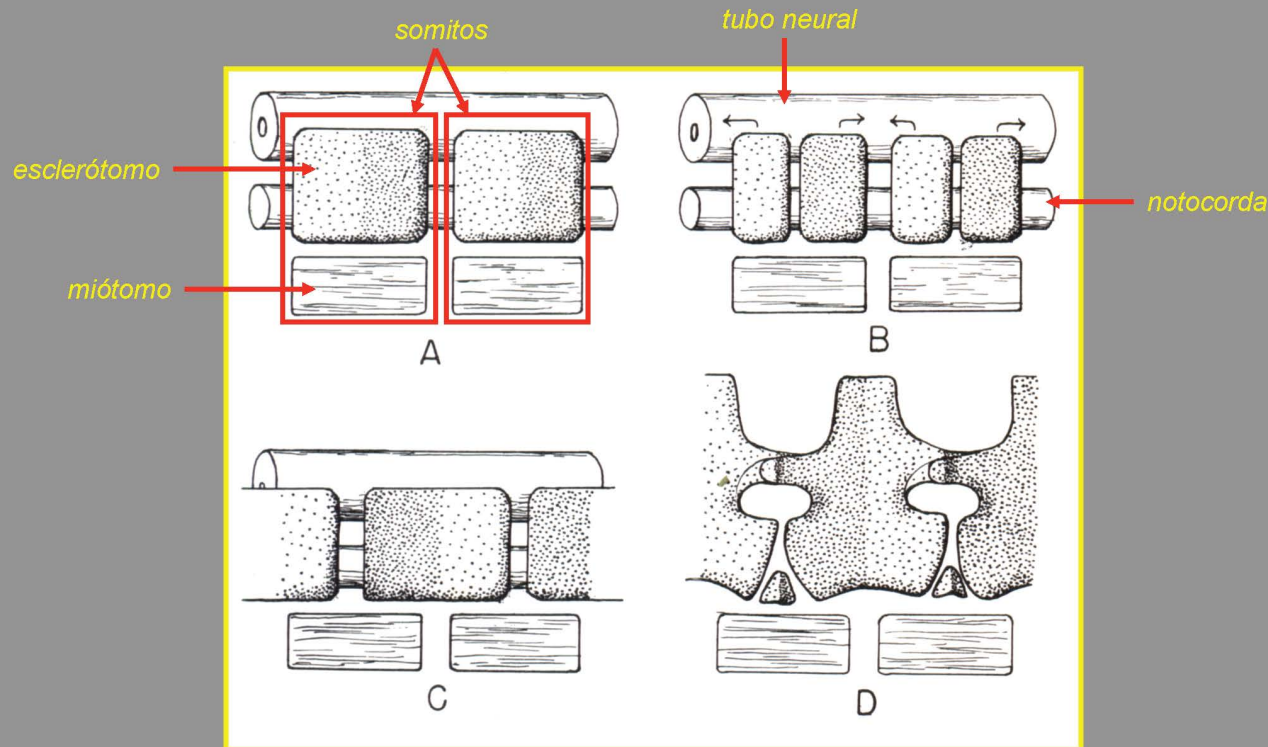
centro: comprime a notocorda

arco hemal: protege a veia e a artéria caudal



A. Chondrichthyan

As vertebrae ossificadas esto em
posio intersegmentar devido  divisio e fuso das
partes anterior e posterior de segmentos adjacentes de
Esclertomos



Esqueleto Axial

costelas: desenvolvem-se nos mioseptos; dão força à parede lateral do corpo (protegem as vísceras) e fornecem ancoradouros para a musculatura do tronco e da cauda; grande variação nos grupos.

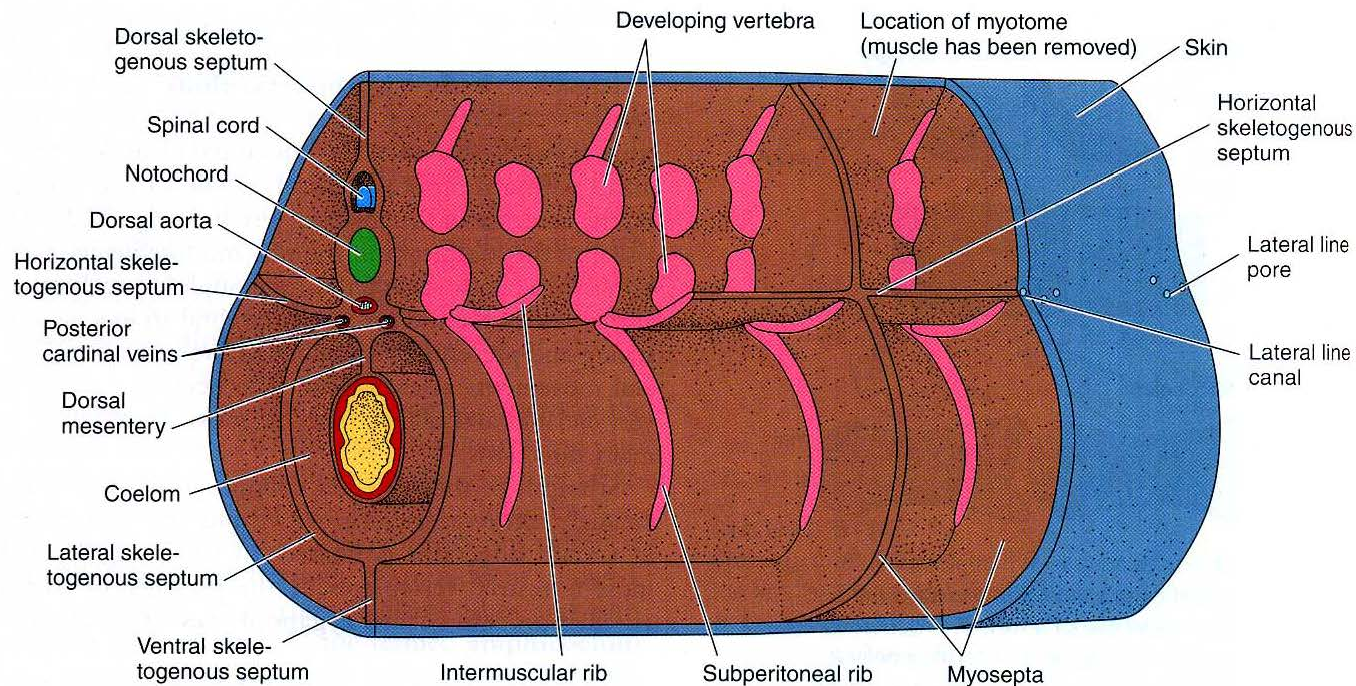
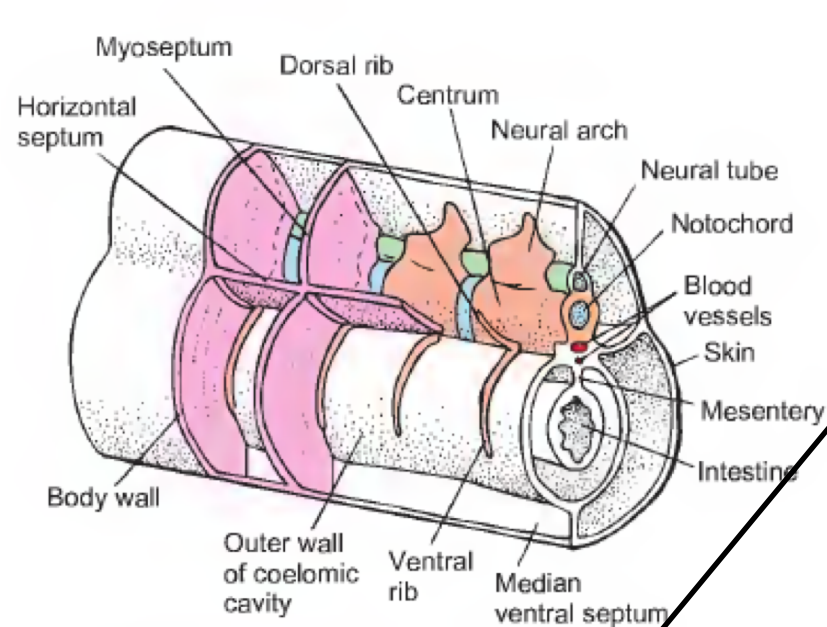


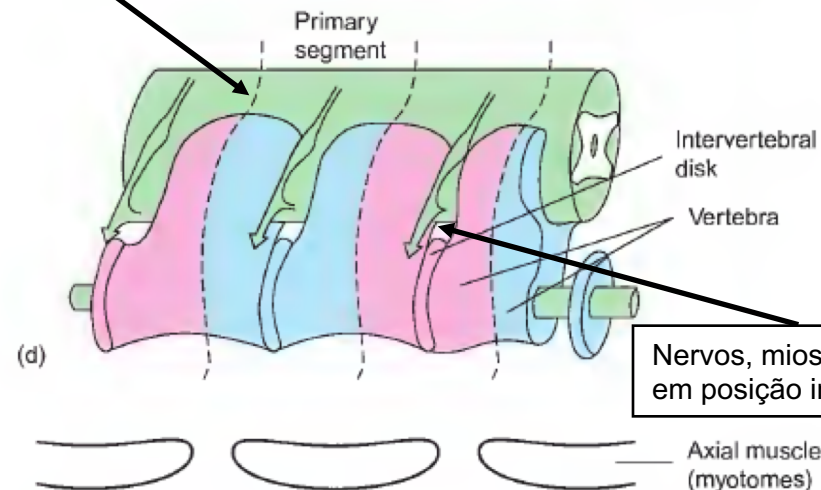
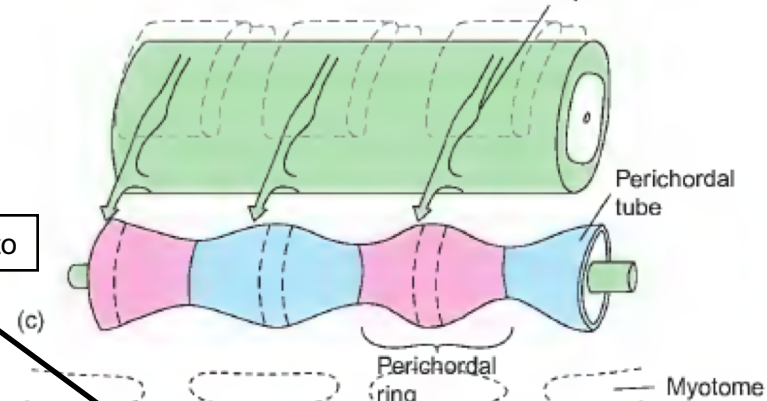
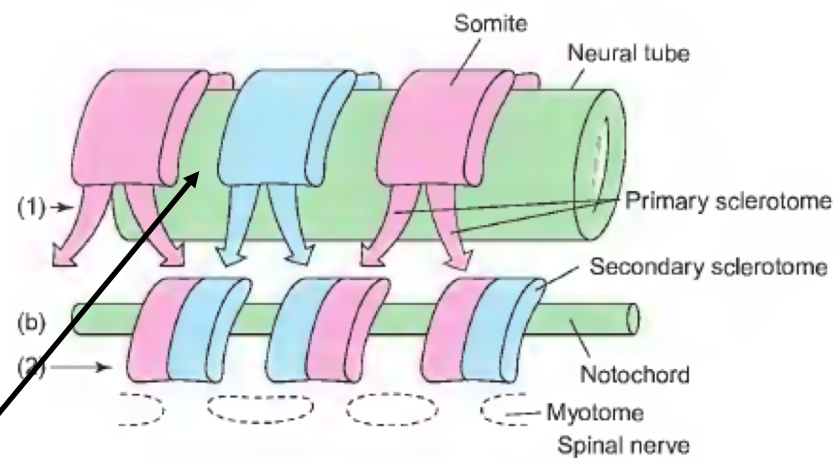
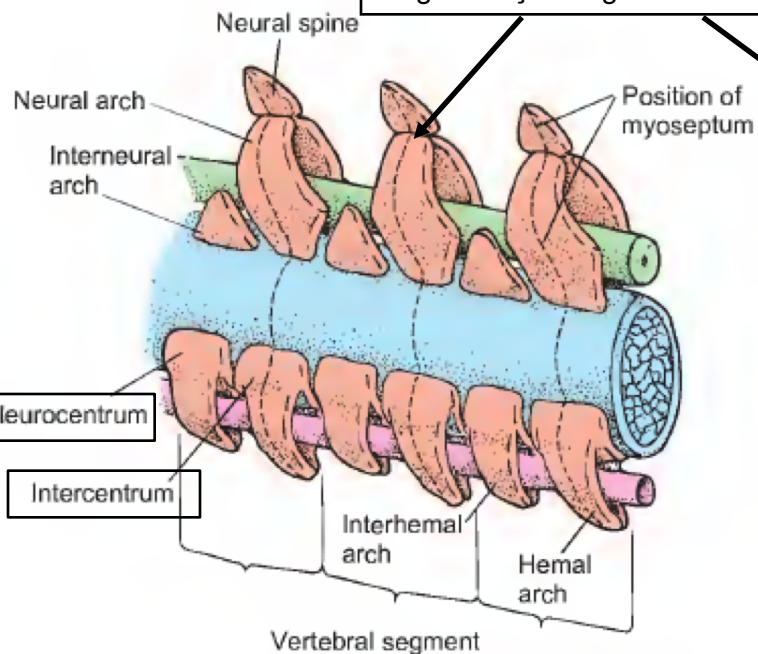
FIGURE 8-3

A stereodigram of the vertebral axis, skeletogenous septa, and ribs of a jawed fish. (After Goodrich.)

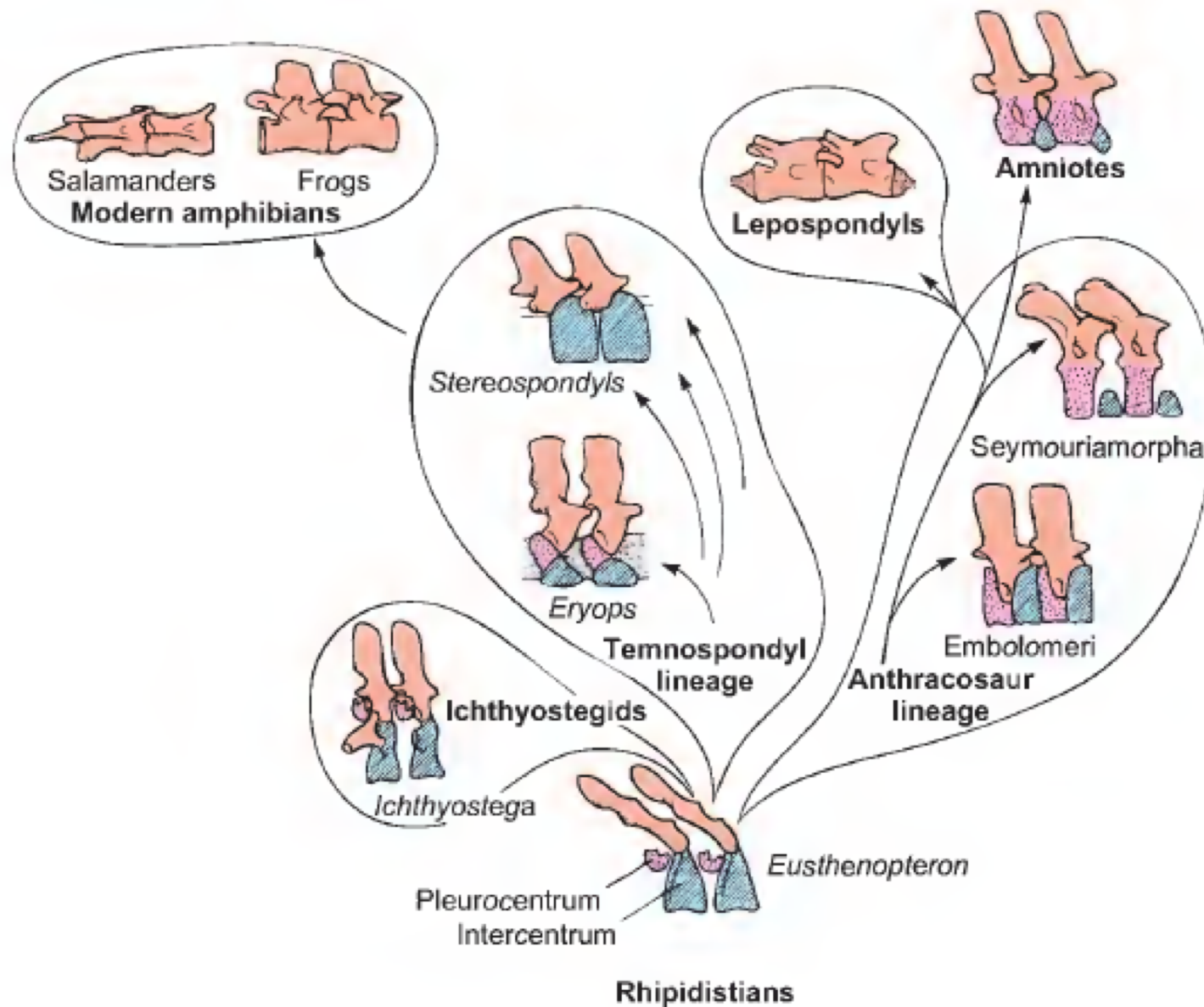


(a) Fish ribs

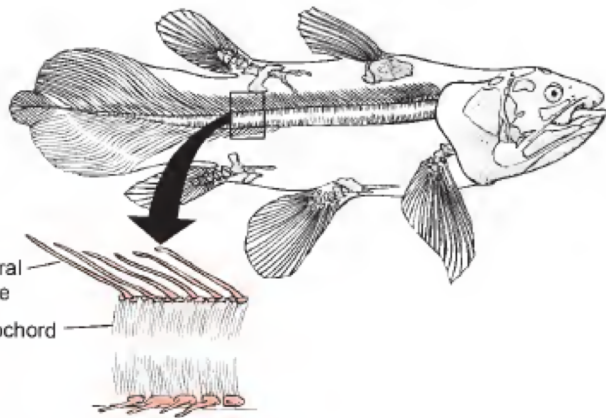
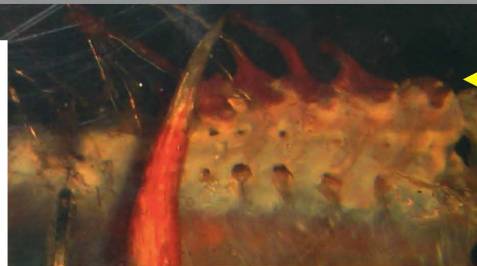
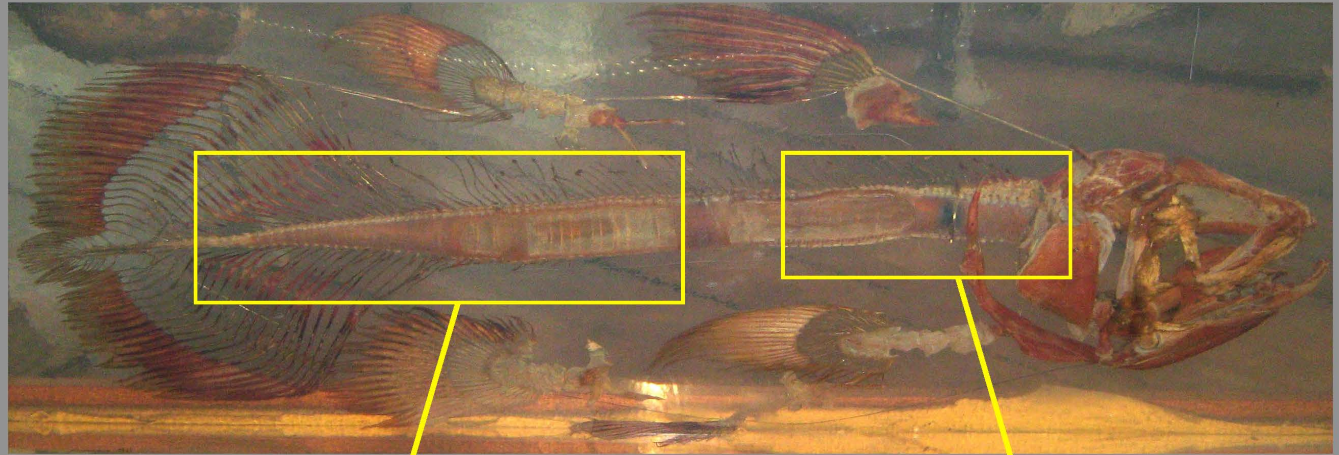
Segmentação original do somito



Nervos, mioseptos e costelas em posição intervertebral



Latimeria: esqueleto: notocorda



Neural spine
Notochord

(a) *Latimeria*

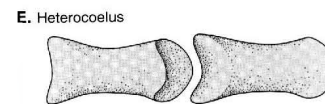
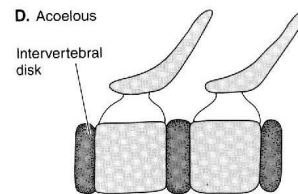
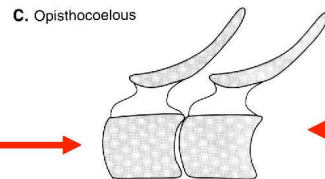
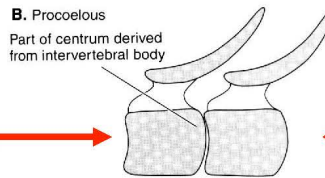
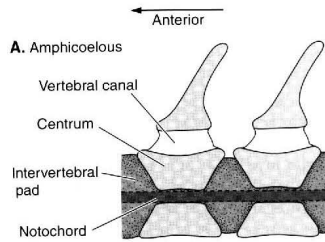
Exemplar de *Latimeria* do Museu de Paris

Esqueleto Axial

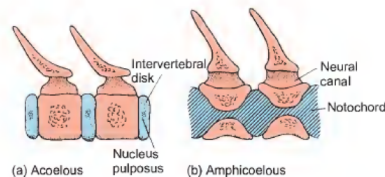
Tipos de vértebras

cótilo: região da concavidade

côndilo: região da convexidade



E 8-2
if vertebral centra; anterior is toward the left.
A, Amphicoelous vertebrae of a fish. B, Procoelous
vertebrae of an early sauropsid. C, Opisthocoelous
vertebrae of an early sauropsid. D, Acoelous vertebrae
normal. E, Dorsal view of the centra of two
heterocoelous cervical vertebrae of a bird. (E, After Wake)



anficélicas: peixes

procélicas: maioria dos répteis e anfíbios

opistocélicas: alguns répteis e anfíbios

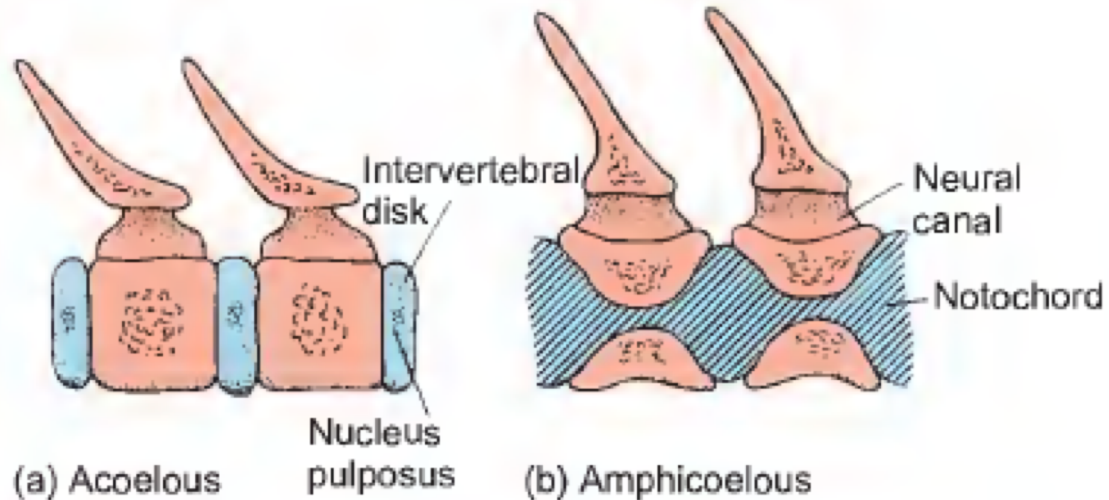
acélicas: mamíferos

heterocélicas: aves e pescoço das tartarugas (maior amplitude de movimento)

heterocélicas: aves e pescoço das tartarugas (maior amplitude de movimento)

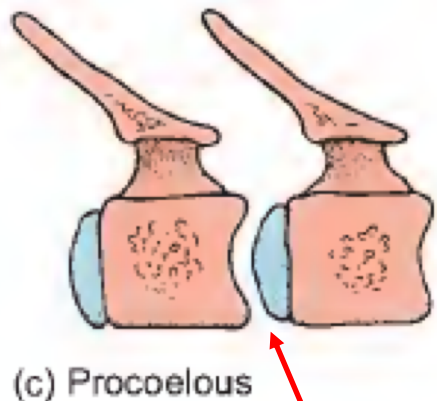
TIPOS DE VERTEBRAS

Acélicas =
mamíferosx

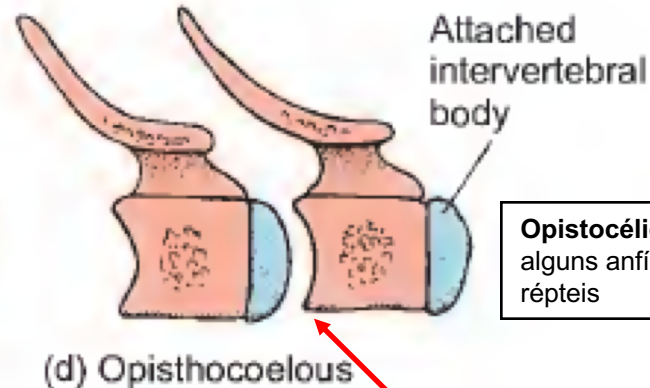


Anficélica =
peixes

Procélicas =
maioria dos
anfíbios e répteis



Côndilo = Região de convexidade



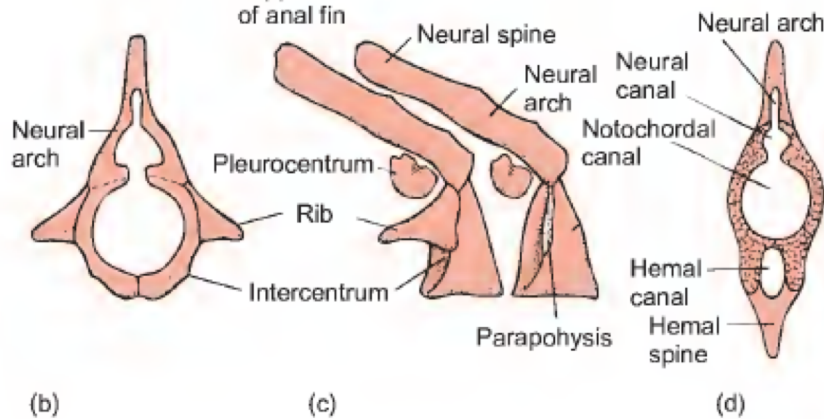
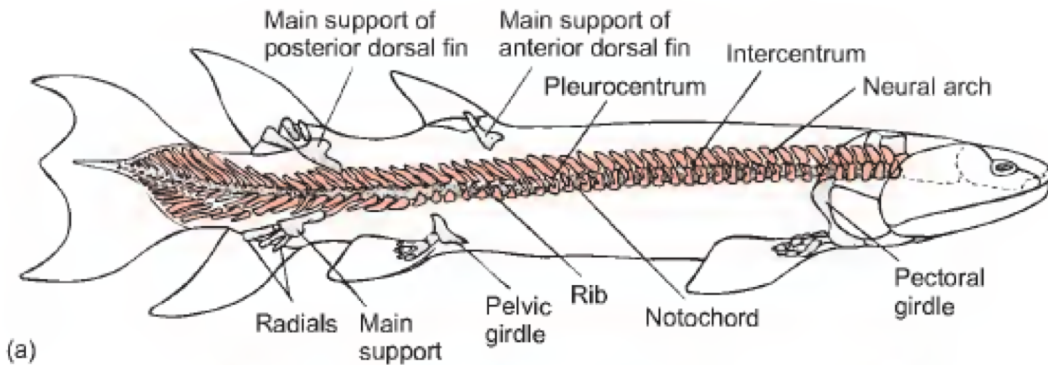
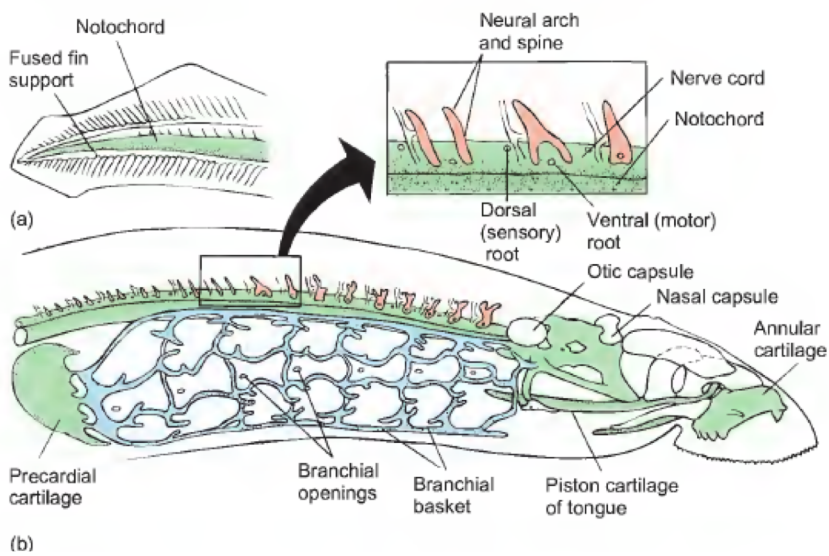
Cótilo = Região de concavidade

Opistocélicas =
alguns anfíbios e
répteis

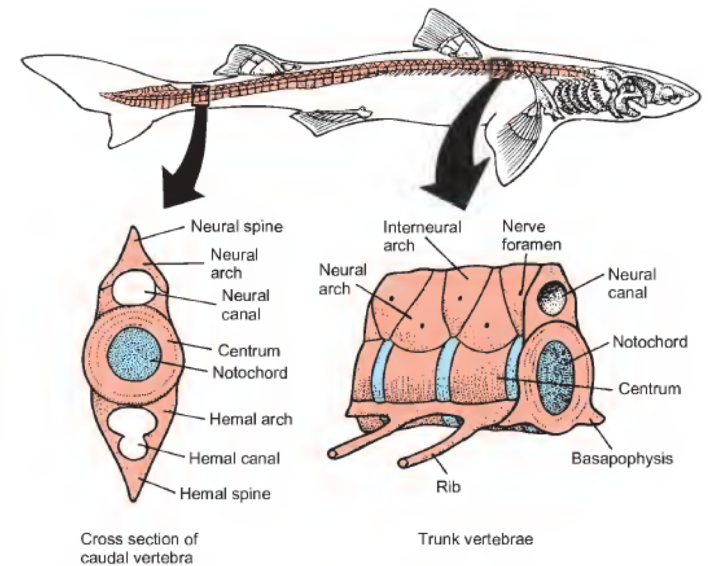
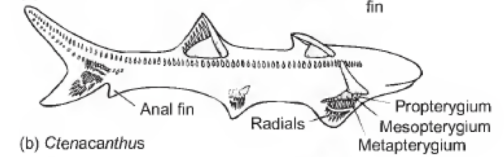
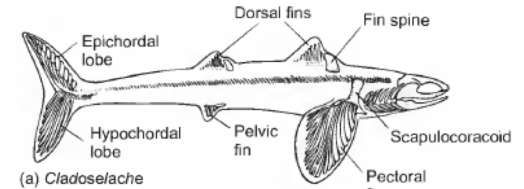


Heterocélicas =
aves e pescoço
das tartarugas

(e) Heterocoelous

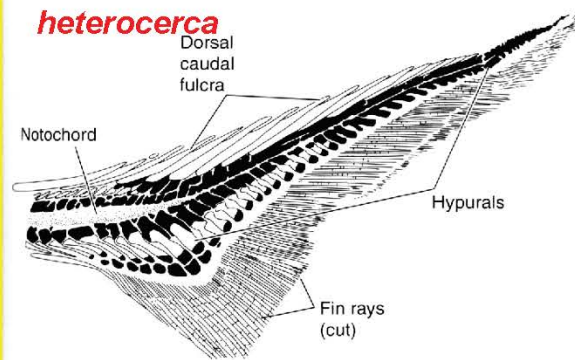


"PEIXES"

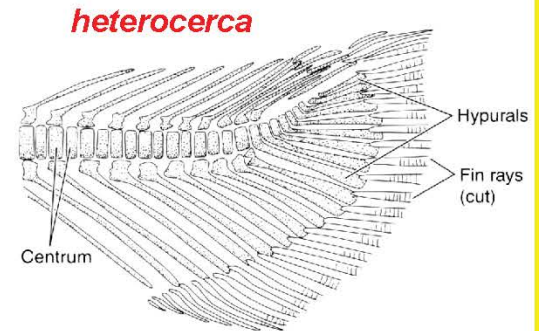


Esqueleto Axial

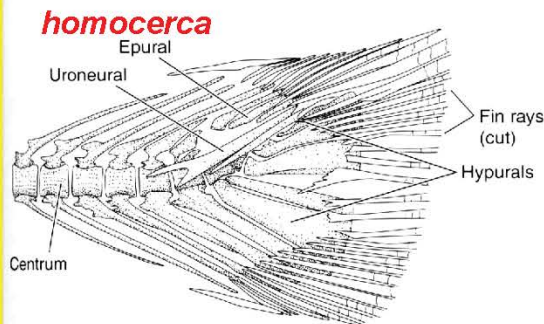
peixes: menos variação nas vértebras; região de transição: monospondilia e diplospondilia (vértebras menores); notocorda persistente em muitos



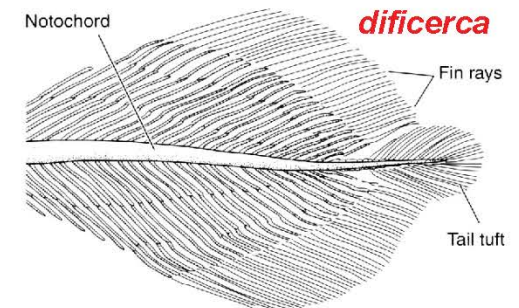
A. Caudal skeleton of *Polyodon* (heterocercal)



B. Caudal skeleton of *Amia* (abbreviated heterocercal)



C. Caudal skeleton of *Elops* (homocercal)



D. Caudal skeleton of *Latimeria* (diphycercal)

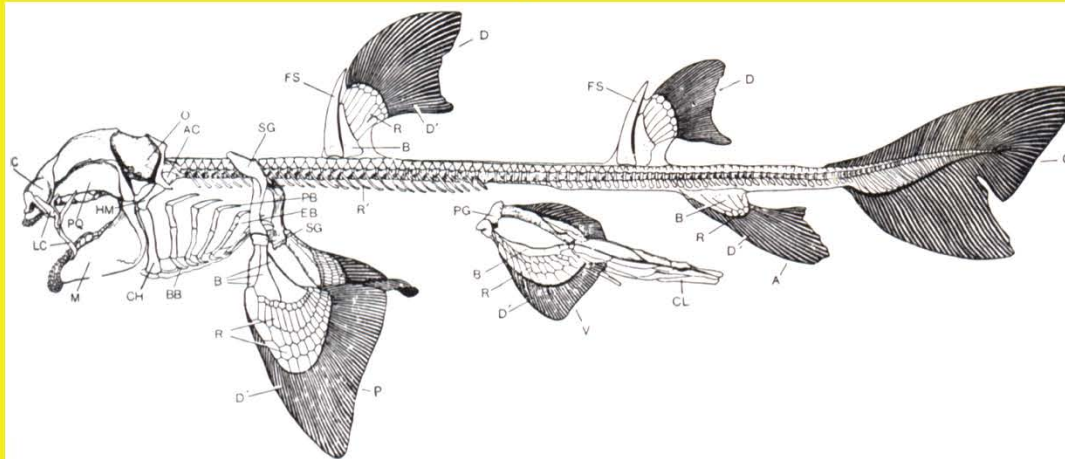


FIGURE 8-10

Major caudal fin and caudal skeleton types of bony fishes.

A. Heterocercal caudal fin of a paddlefish, *Polyodon*.

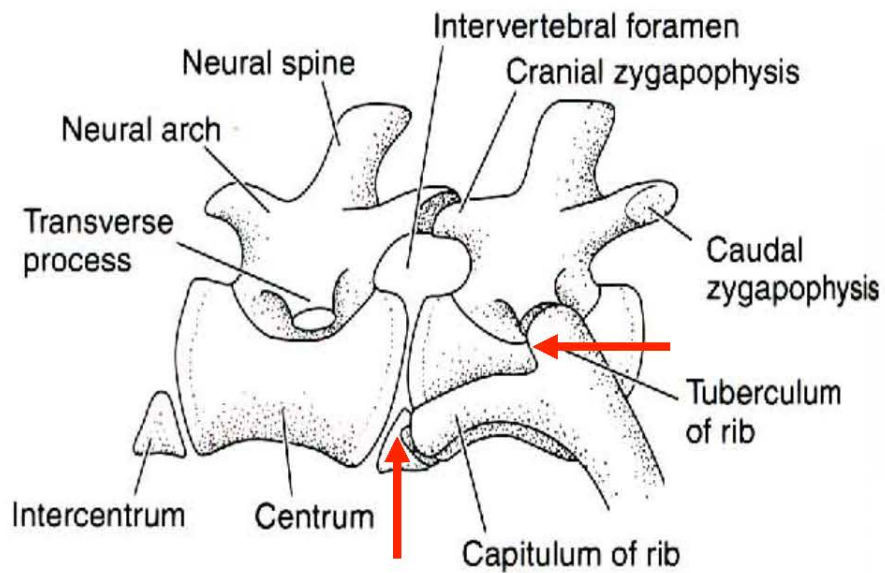
B. Abbreviated heterocercal caudal fin of a bowfin, *Amia*.

C. Homocercal caudal fin of a ladyfish, *Elops*. D. Diphycercal

caudal fin of a coelacanth, *Latimeria*. E. Caudal fin evolution in bony fishes; a heterocercal tail is plesiomorphic. Within actinopterygians, abbreviated heterocercal and homocercal tails evolved. Diphycercal types evolved independently in sarcopterygians (e.g., coelacanths and lungfishes) and in actinopterygians (e.g., cods and many eel-like teleosts). (A, After Grande and Bermis; B and C, after Patterson; D, after Jarvik.)

Esqueleto Axial

Estrutura das vértebras

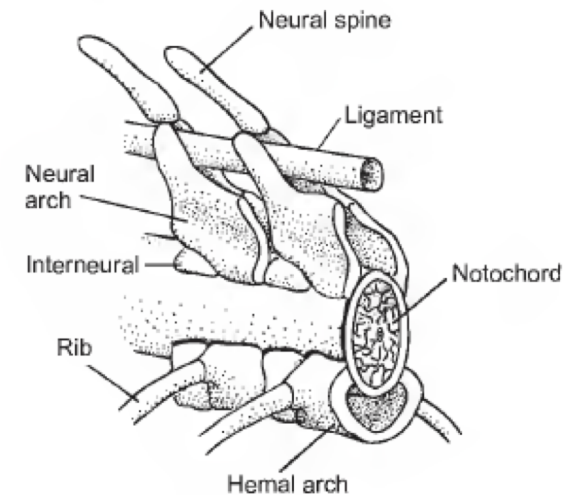


B. Reptilomorph

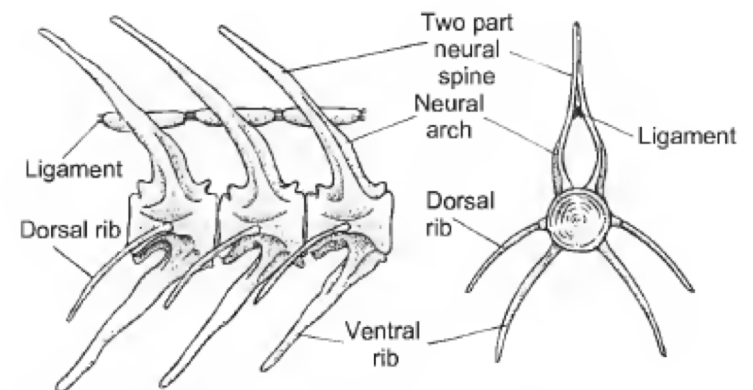
articação dupla

Tetrapoda

Actinopterygi



(a) Sturgeon vertebrae (lateral)



(b) Teleost vertebrae (lateral)

(c) Teleost vertebra (cross section)

Tetrapodomorpha

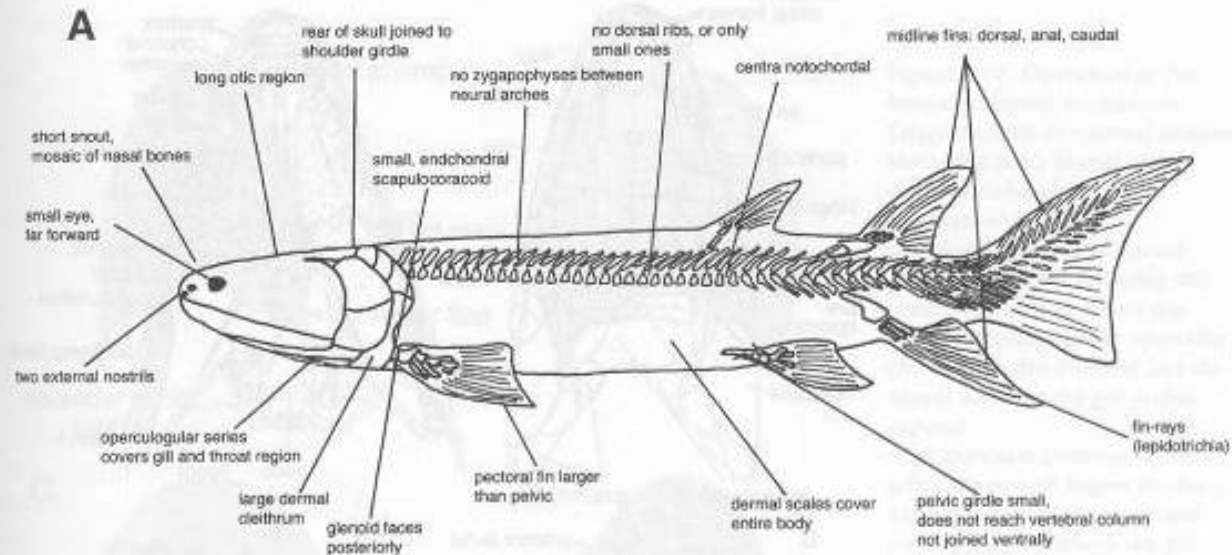
focinho longo narina ext. única

cintura escapular se dissocia do crânio (atlas+axis+região cervical)

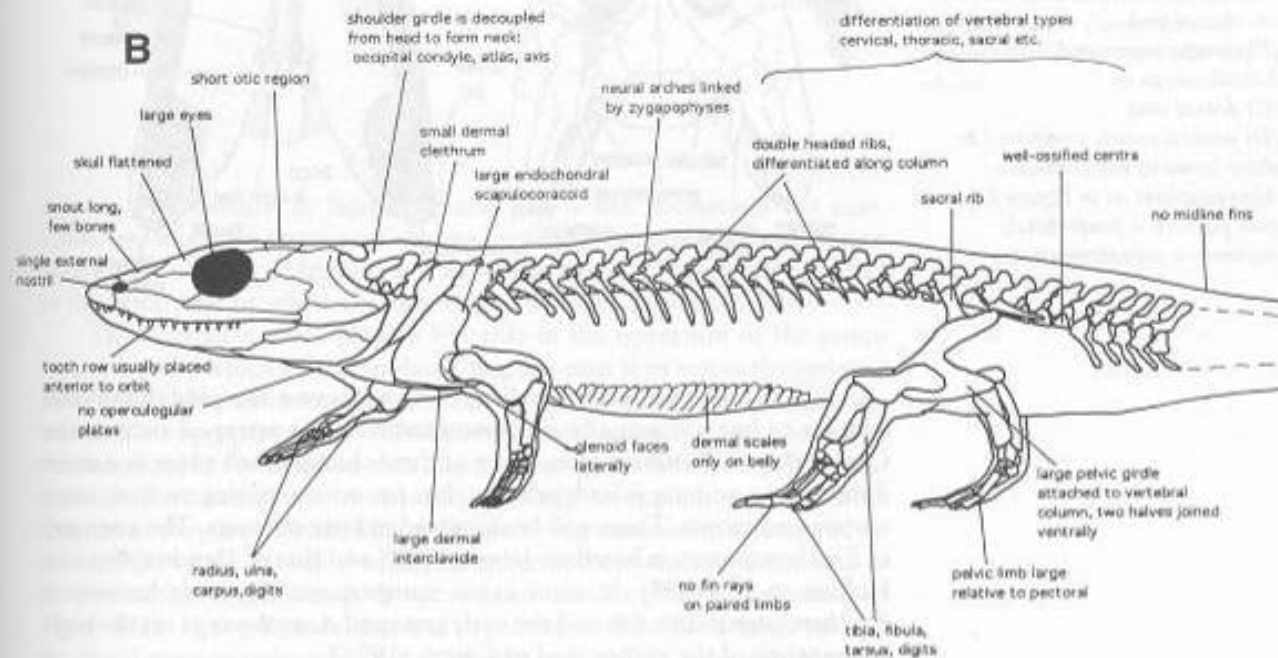
arco neural e centro ligados pelas zigapófises

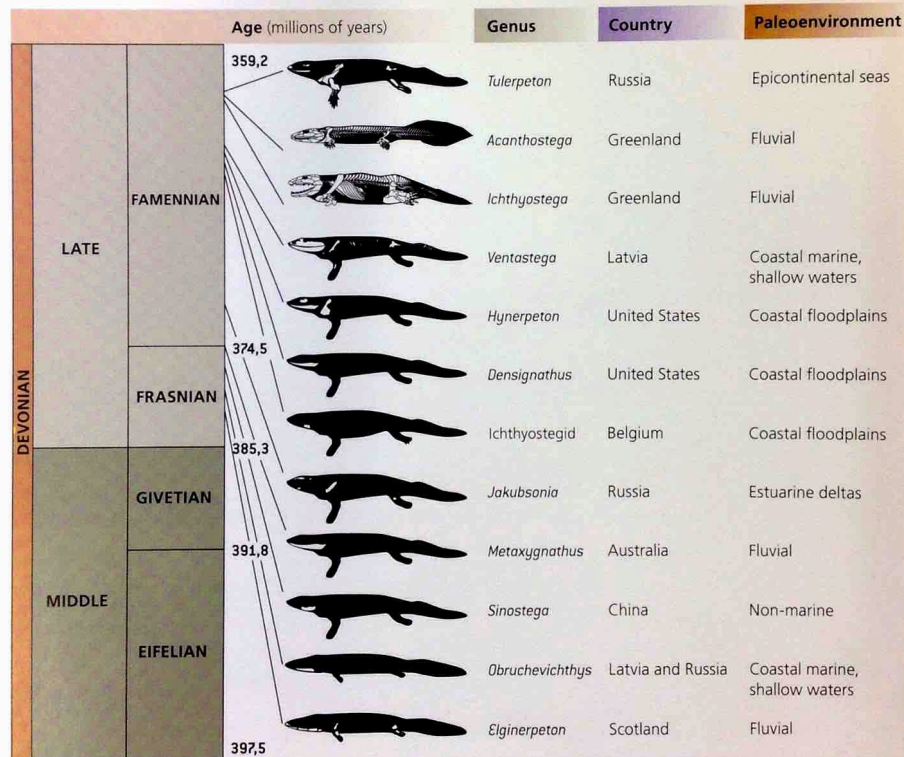
diferenciação vertebral (regiões cervical, torácica, sacral, caudal)

Diferenciação dos zeugopódios e autopódios (radius, ulna, carpus, dígitos) (tíbia, fíbula, tarsus, dígitos)



Transição para o padrão básico de um tetrápode

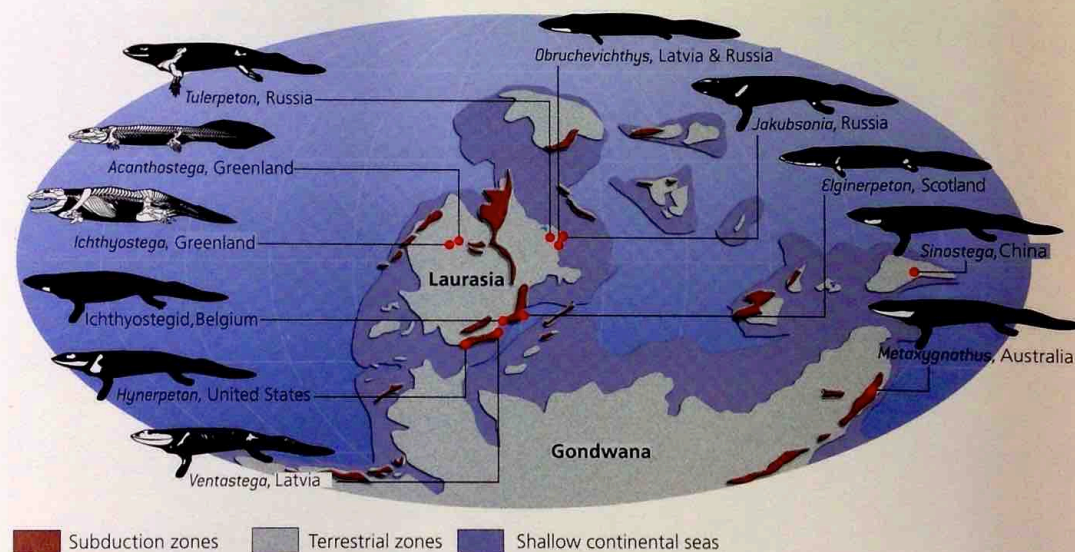
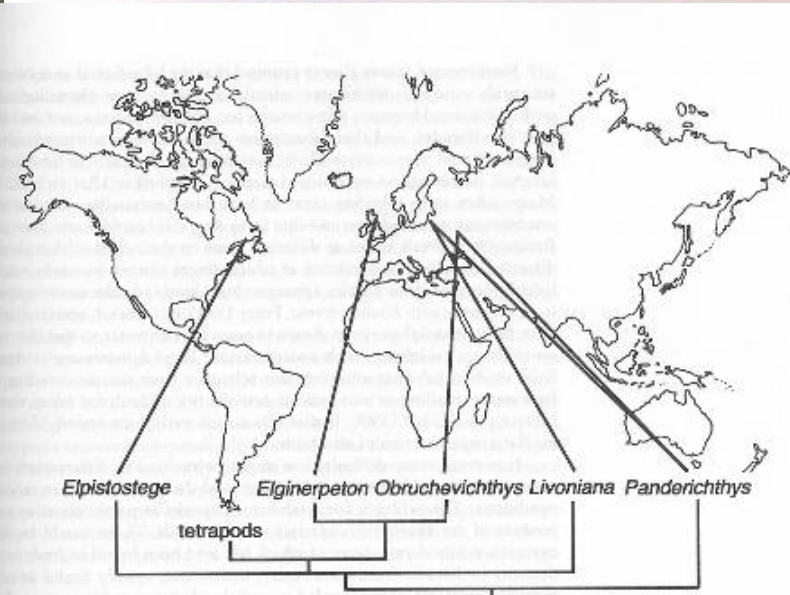
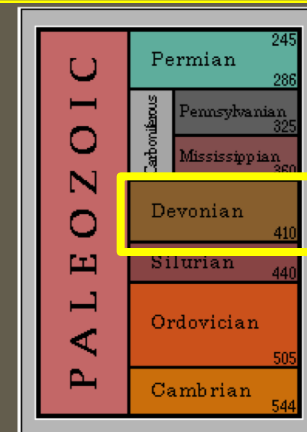




Devoniano (417 – 354 Ma)

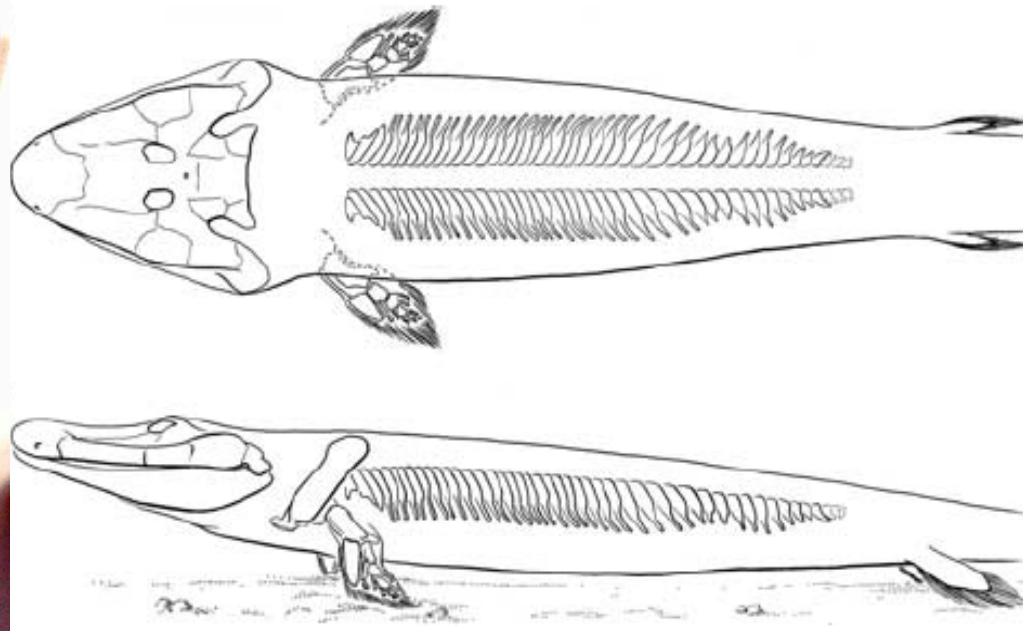
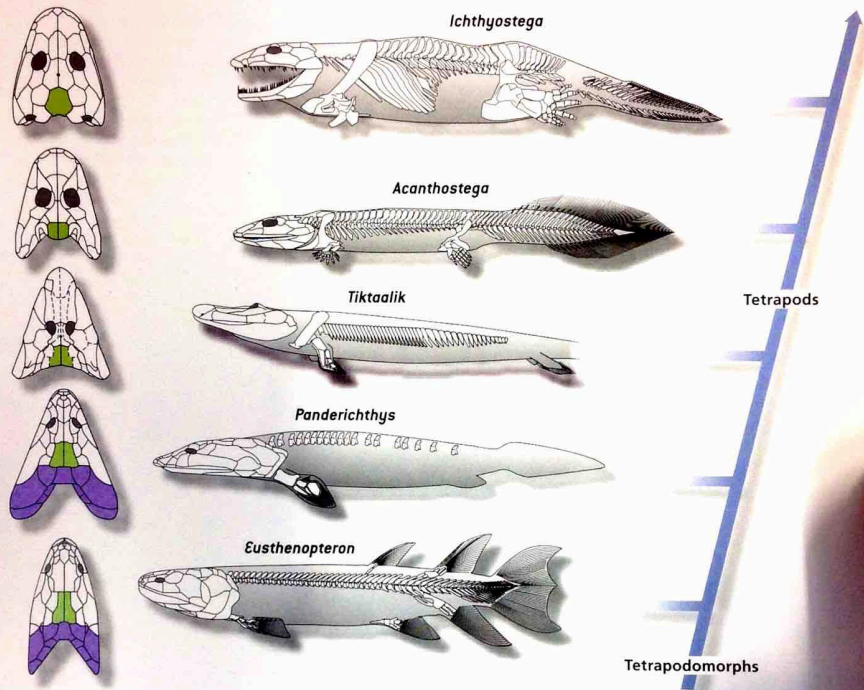
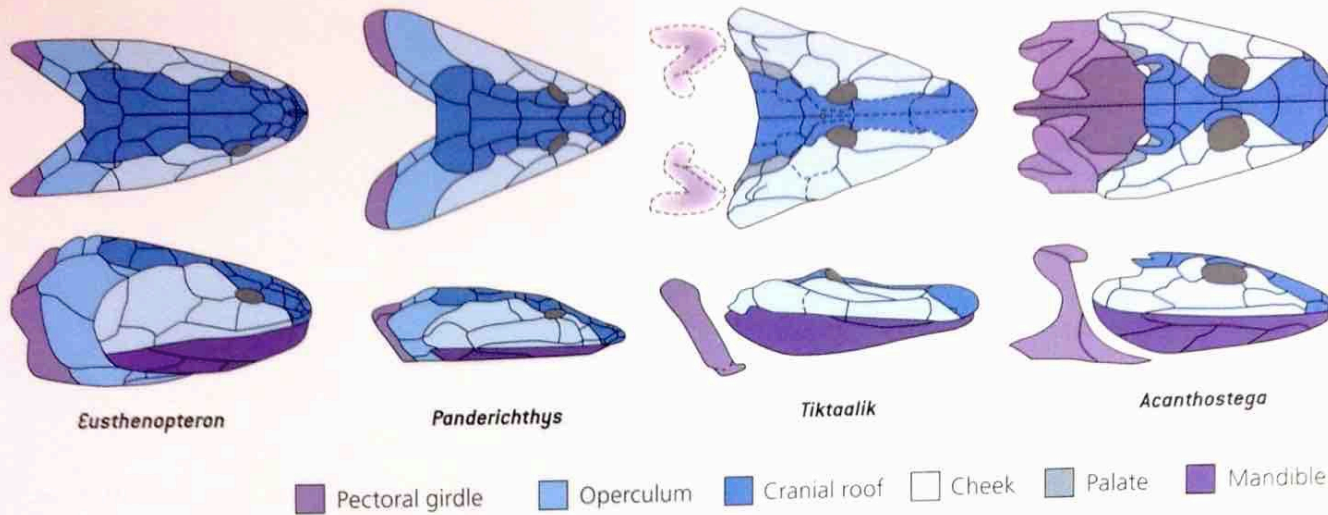
Origem da linhagem Tetrapodomorpha no Devoniano Superior

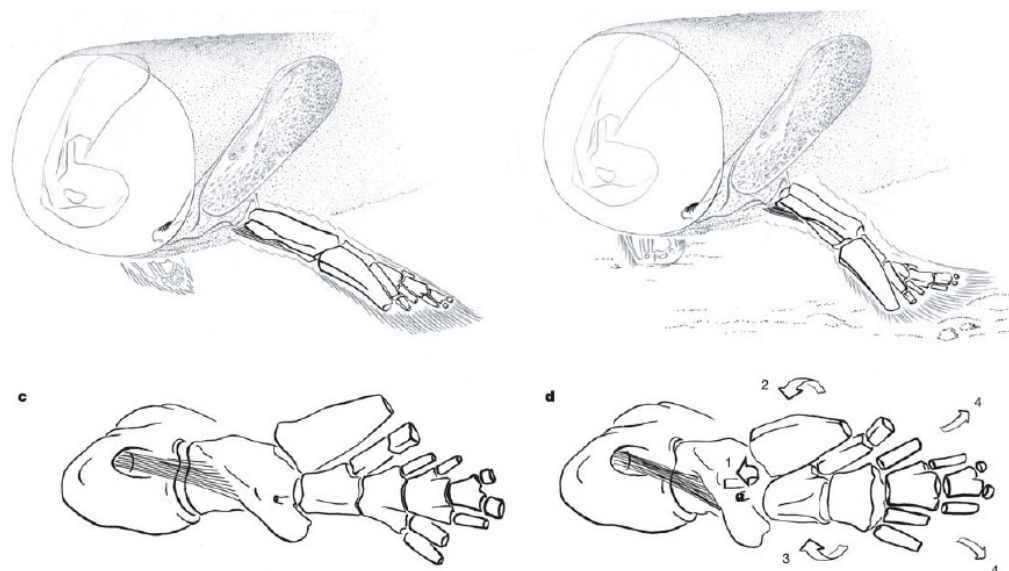
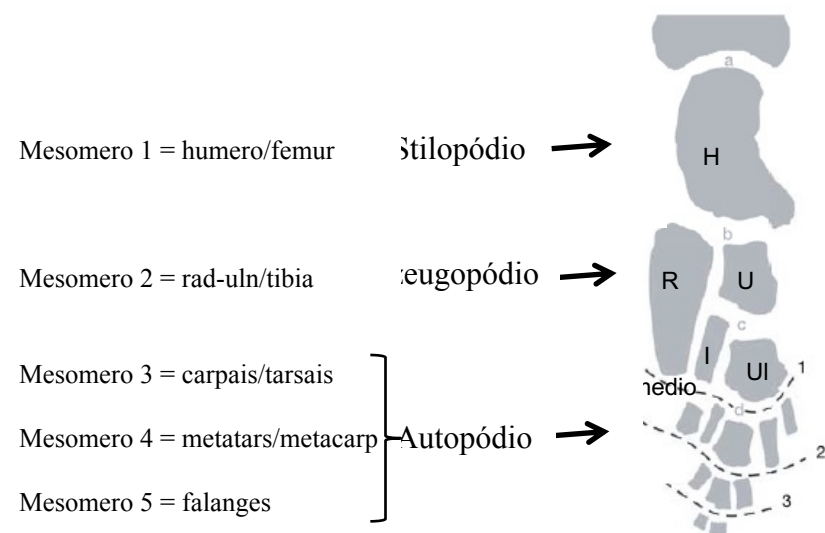
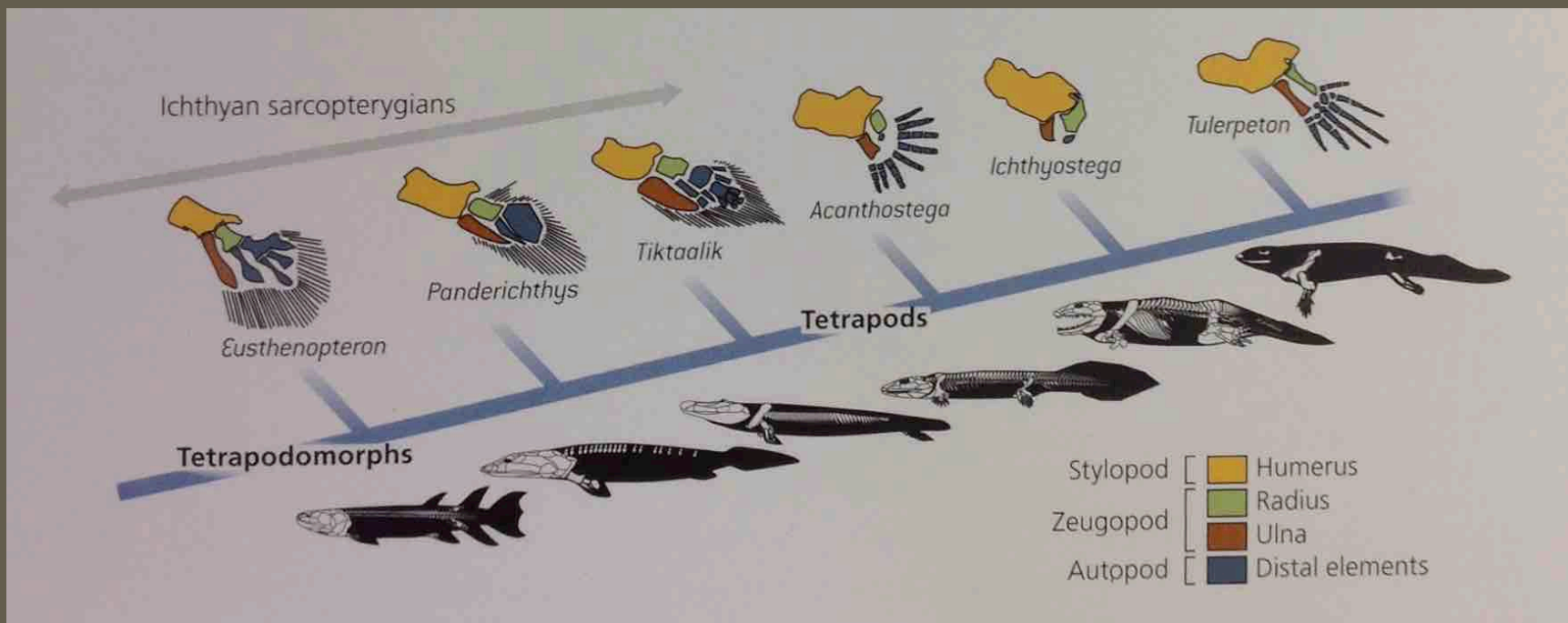
Curto intervalo temporal sugere que a transição para o ambiente terrestre ocorreu rapidamente



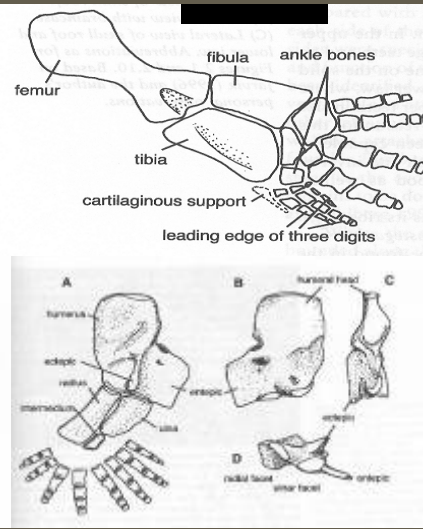
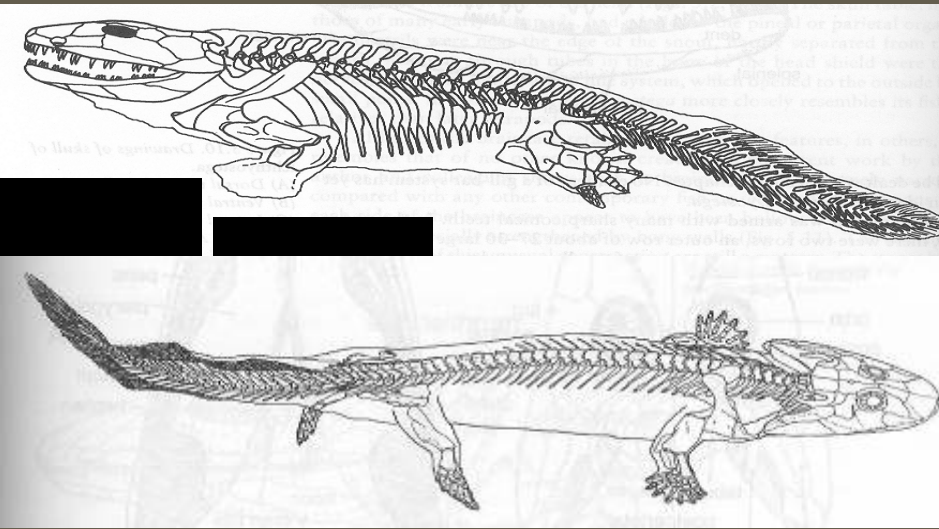
Sinapomorfias compartilhadas por *Tiktaalik* e Tetrapodas

- perda dos ossos operculares
- liberação da cintura escapular
- focinho alongado
- Diferenciação dos autopódios (carpus, digitos)





Os Stem-Tetrapoda do Famenniano (365 MAA) e a primeira irradiação de tetrápodes



Ichthyostega

- arcos branquiais ausentes
- dentes labirintodontes
- costelas expandidas
- 7 dedos no pé

Acanthostega

- dentes não labirintodontes
- 3 arcos branquiais
- 8 dedos no pé

[illegible]

Caracteres derivados

zeugopódios e autopódios totalmente diferenciados
(radius, ulna, carpus, digitos)
(tíbia, fíbula, tarsus, digitos)

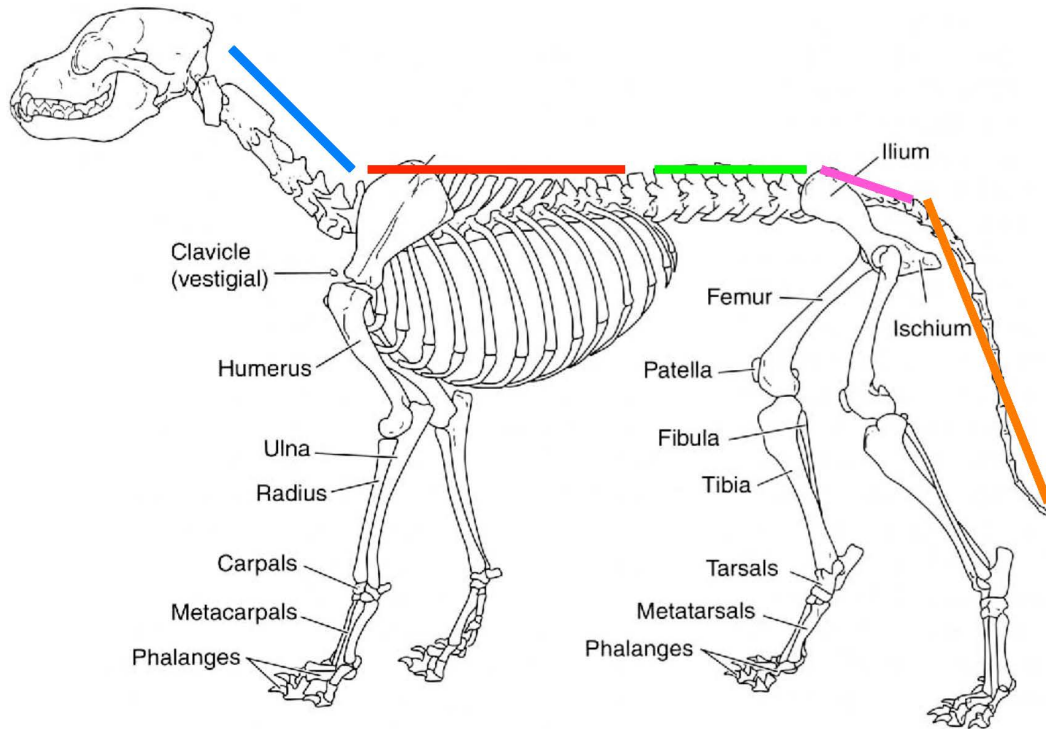
cinturas fortemente ancoradas ao esqueleto axial

região cervical diferenciada

costelas com 2 facetas articulares

Esqueleto Axial

tetrápodes: coluna subdividida em tipos distintos de vértebras, especialmente mamíferos:
cervical → *torácica* → *lombar* → *sacral* → *caudal*



A. Skeleton of a dog (*Canis*) in standing posture

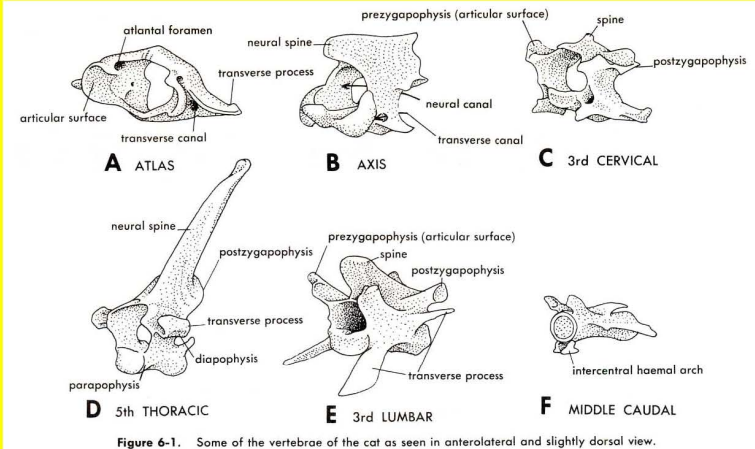
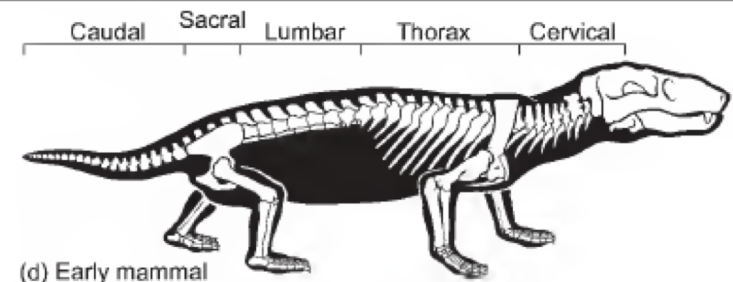


Figure 6-1. Some of the vertebrae of the cat as seen in anterolateral and slightly dorsal view.

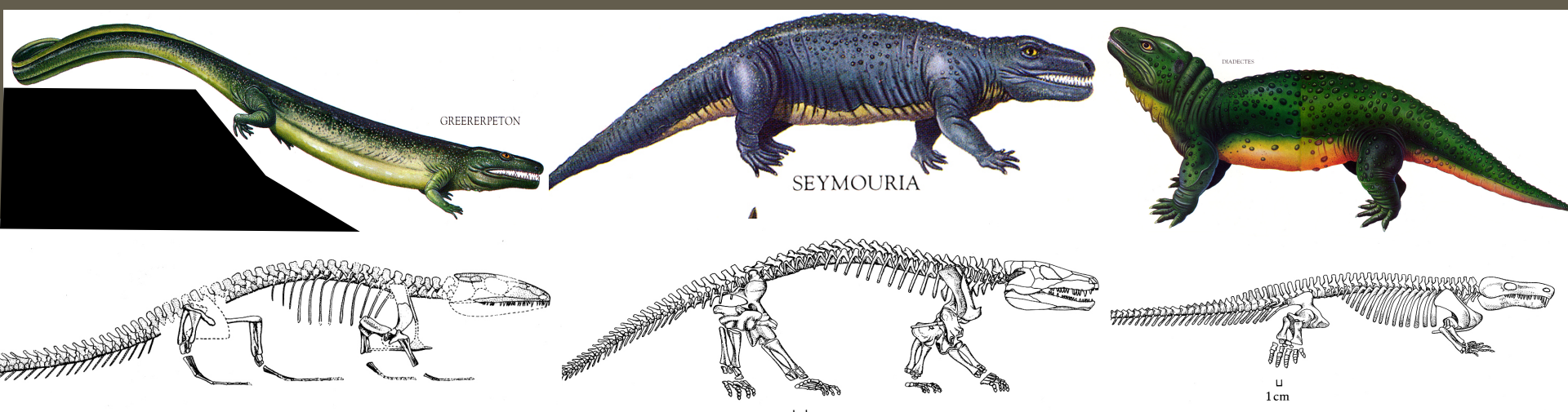
mamífero: gato



Smithson (1982):

Batrachomorpha (Temnospondyli e Lepospondyli) **Exoccipitais proeminentes, pleurocentro**

Reptiliomorpha (Anthracosauria, Seymouriamorpha, Diadectomorpha) **Opisthóticos proeminentes, intercentro**

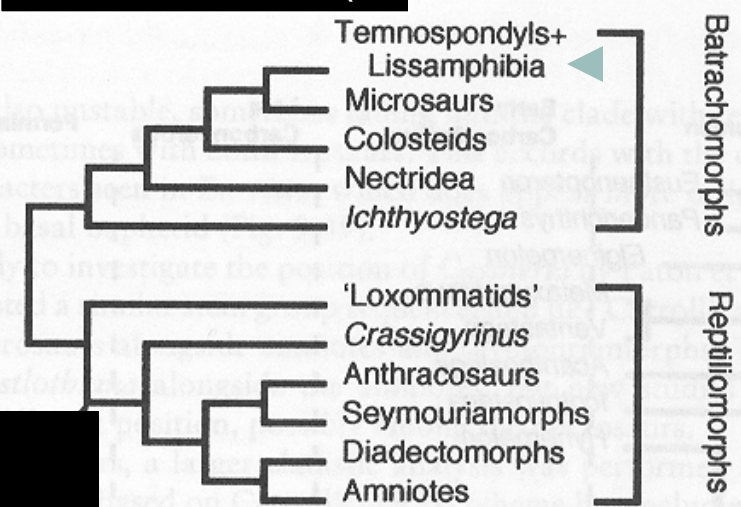


BATRACHOMORPHA

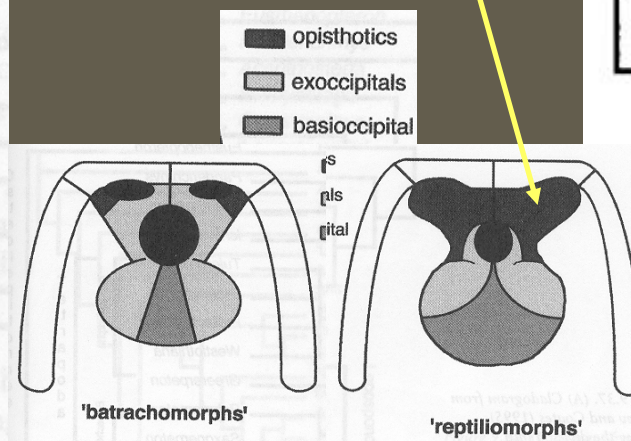
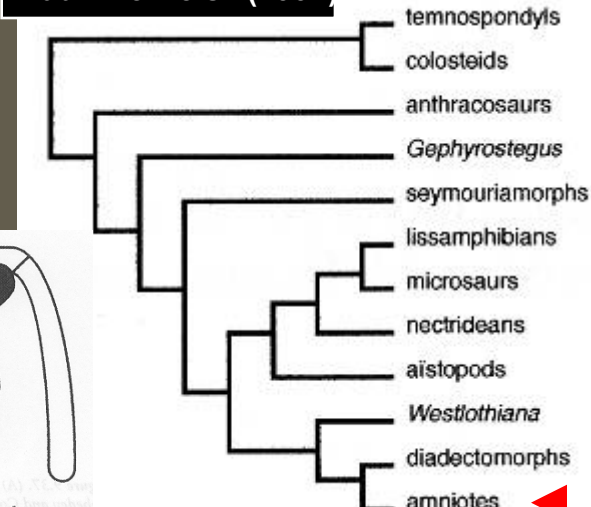
REPTILIOMORPHA

Opisthóticos proeminentes conectados ao dermatocranio

Panchen e Smithson (1988)



Laurin e Reisz (1997)

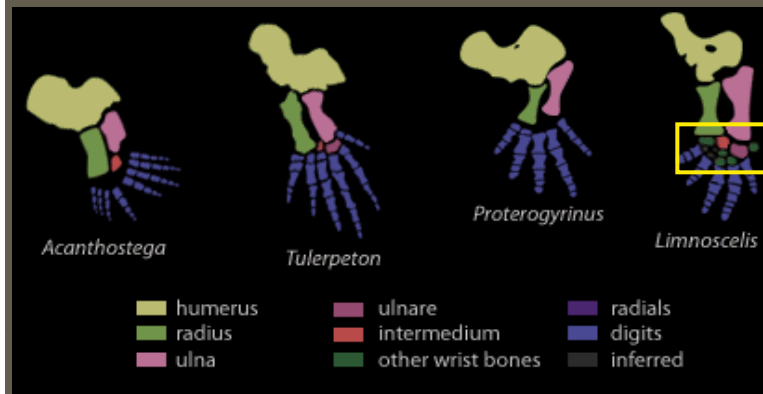
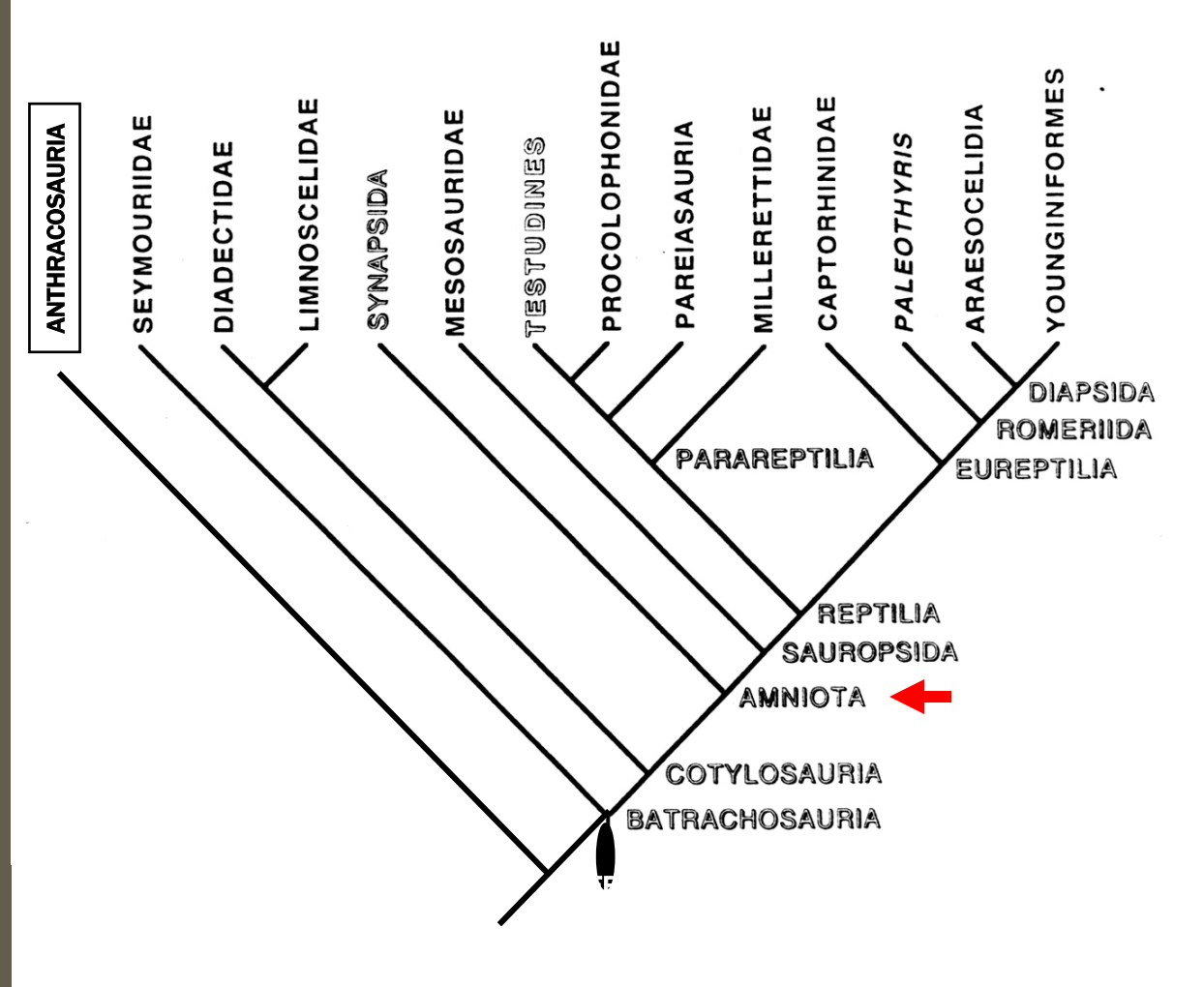
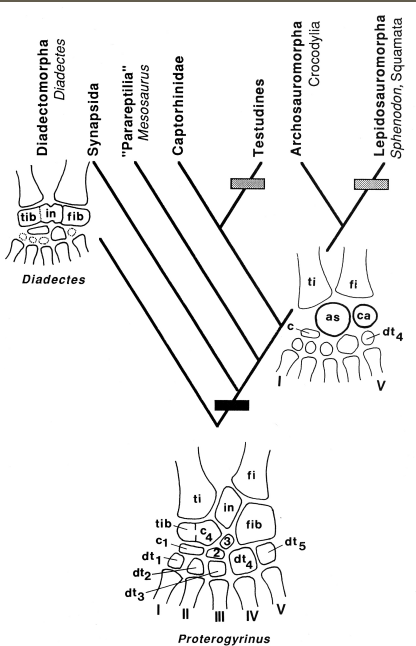


Sinapomorfias de Amniota

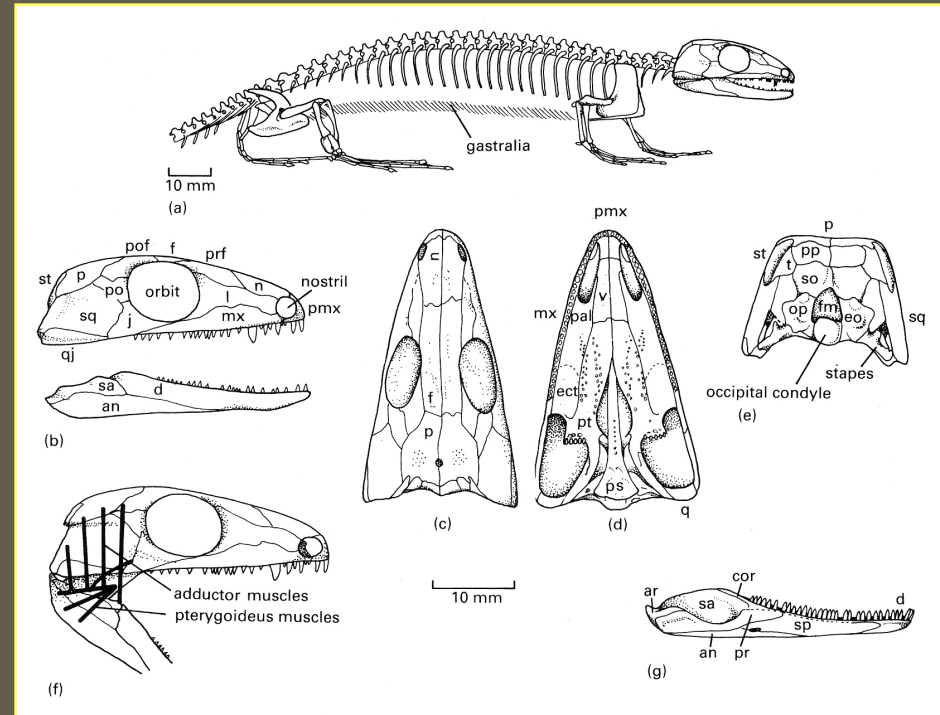
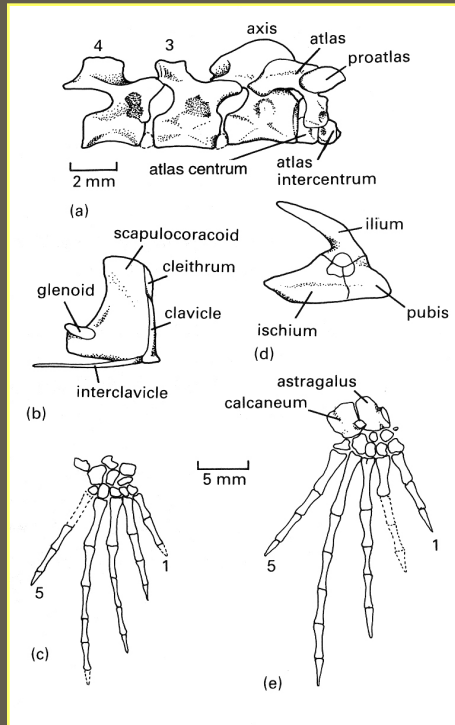
sacro com 2 vertebras



astragalus presente no pé.



TRAÇOS ANATÔMICOS DO MAIS ANTIGO AMNIOTA



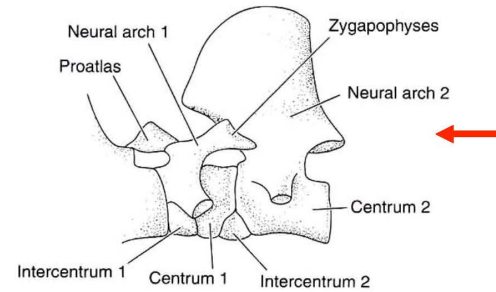
- 200 mm com cabeça proporcionalmente pequena
- columela robusta
- tabular e posparietal presentes
- scapulocoracoide e pelvis robustos
- astragalo e calcaneo presentes

Esqueleto Axial

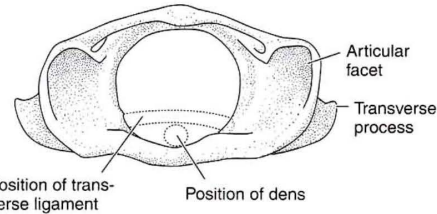
Estrutura das vértebras

-mamíferos: atlas e áxis modificados, maior movimentação da cabeça

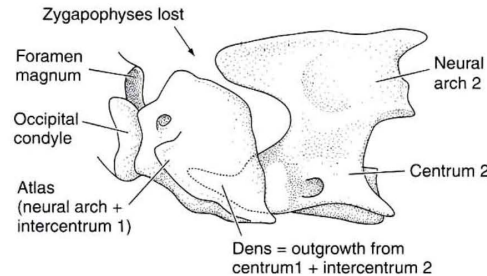
-mamíferos: 7 vértebras cervicais (até na girafa), com 3 exceções (preguiça de 2 dedos e peixe-boi com 6, e preguiça de 3 dedos com 9)



A. Atlas of †*Dimetrodon*



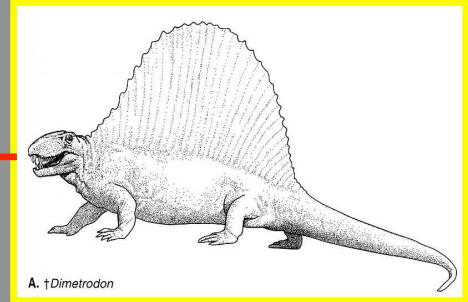
B. Atlas of a mammal, anterior view



C. Atlas and axis complex of a mammal, lateral view

FIGURE 8-19

Evolution of the atlas and axis. A, A lateral view of the first two cervical vertebrae of an early synapsid, †*Dimetrodon*. B, An anterior view of the atlas of a mammal. C, A lateral view of the atlas and axis of a mammal. (A, After Jollie; C, after Romer and Parsons.)



Esqueleto Axial

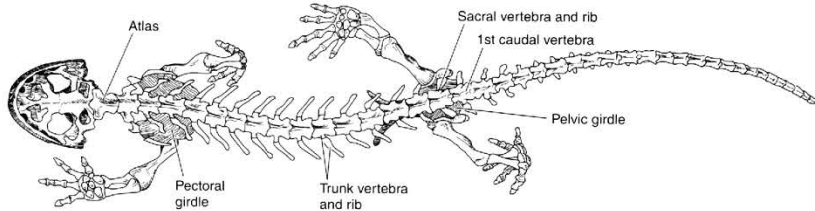


FIGURE 8-13
A dorsal view of the skeleton of a salamander, showing regional specialization of the vertebral column. (From Romer and Parsons, after Schaeffer.)

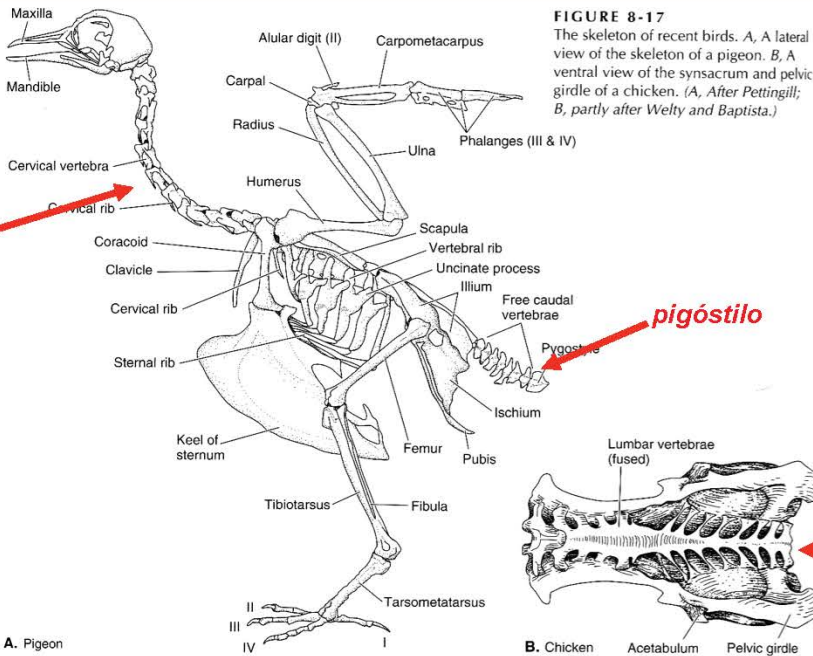


FIGURE 8-17
The skeleton of recent birds. A, A lateral view of the skeleton of a pigeon. B, A ventral view of the synsacrum and pelvic girdle of a chicken. (A, After Pettingill; B, partly after Welty and Baptista.)

cervicais
numerosas

pigóstilo

synsacro

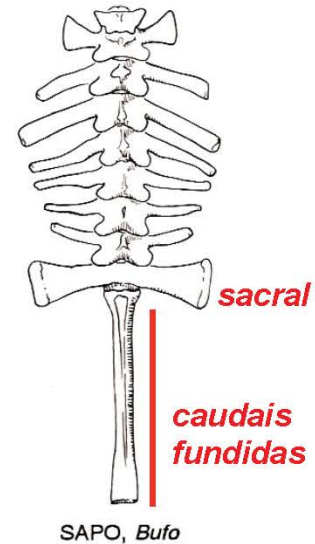
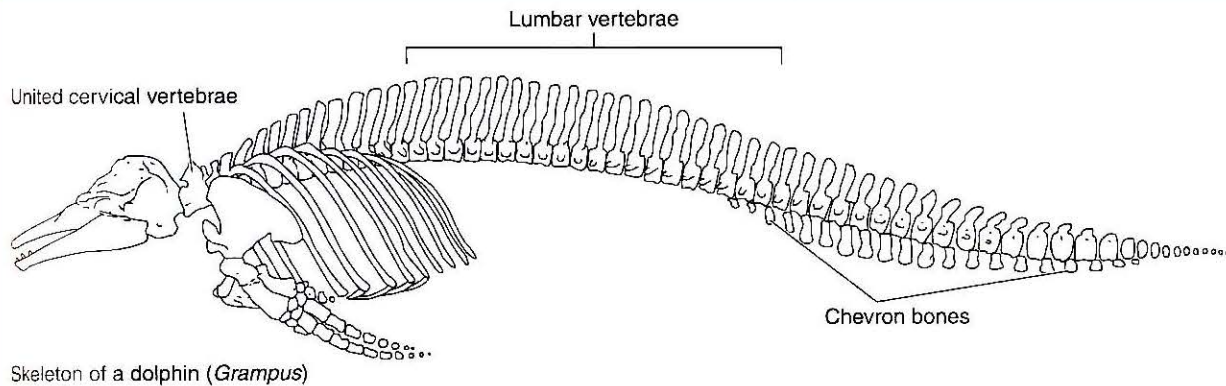


FIGURA 9-7 COLUNA VERTEBRAL DE UM ANURO mostrando, em vista dorsal, a única vértebra cervical, o tronco curto, a ausência de costelas livres, a única vértebra sacral e o urostilo.

Esqueleto Axial

-modificações axiais para a vida em água: cervicais reduzidas, zigapófises reduzidas, arcos neurais alongados (fixação de musculatura propulsora), lombares numerosas.



costelas

Esqueleto Axial

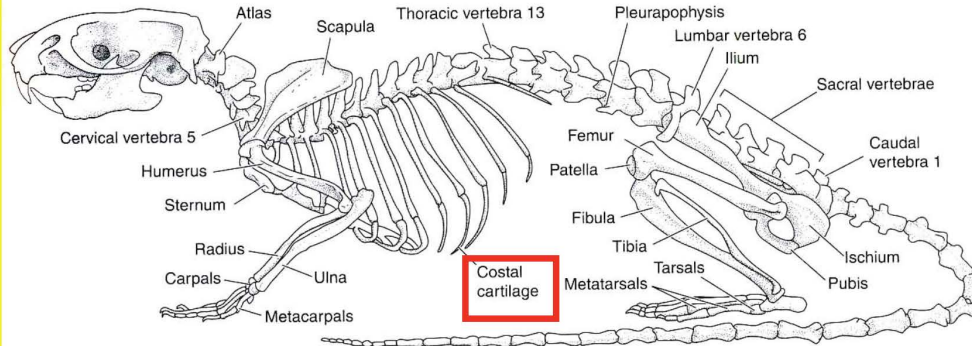
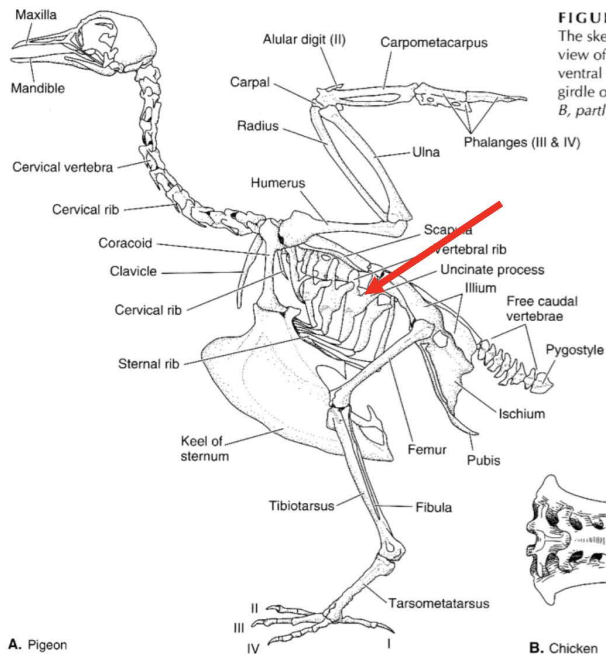
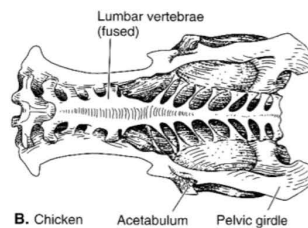


FIGURE 8-18
A lateral view of the skeleton of a rat. (After Hebel and Stromberg.)



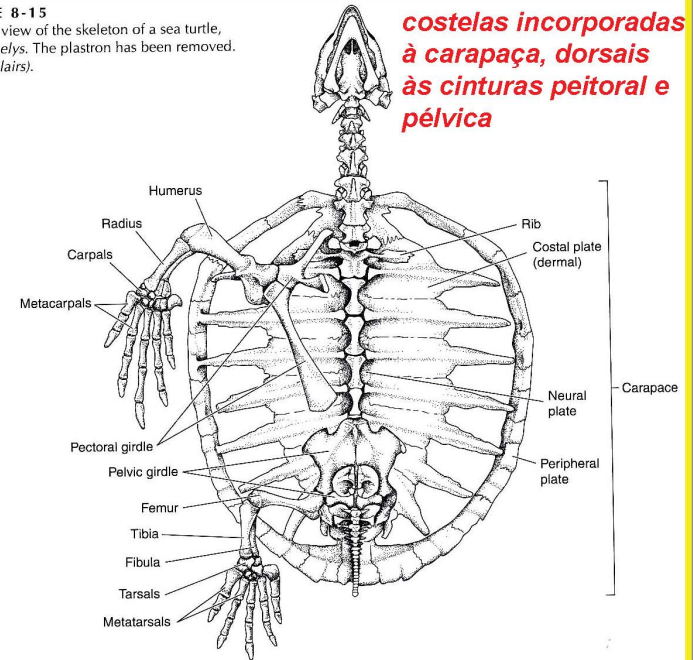
A. Pigeon

FIGURE 8-17
The skeleton of recent birds. A, A lateral view of the skeleton of a pigeon. B, A ventral view of the synsacrum and pelvic girdle of a chicken. (A, After Pettingill; B, partly after Welty and Baptista.)



B. Chicken

FIGURE 8-15
A ventral view of the skeleton of a sea turtle, *Eretmochelys*. The plastron has been removed. (After Bellairs.)



costelas incorporadas à carapaça, dorsais às cinturas peitoral e pélvica



Esqueleto Axial

esterno

- tetrápodes, menos cobras, tartarugas;
- mais desenvolvidos em amniotas onde se unem às costelas por meio de cartilagens costais, protegendo melhor a viscera e participando da ventilação pulmonar;
- âncoradouro para músculos peitorais.

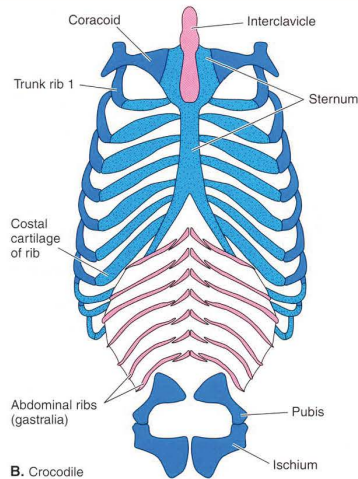


FIGURE 8-7

Ventral views of the sternum of a salamander and a crocodile. *A*, The small, unossified sternum of a salamander lies cranial to the coracoid cartilages of the pectoral girdle. *B*, The costal cartilages of ribs attach to the sternum of a crocodile. *Blue stippled* = cartilage; *blue* = cartilage replacement bone; *red* = dermal bone. (*A*, After Noble; *B*, after Romer and Parsons.)

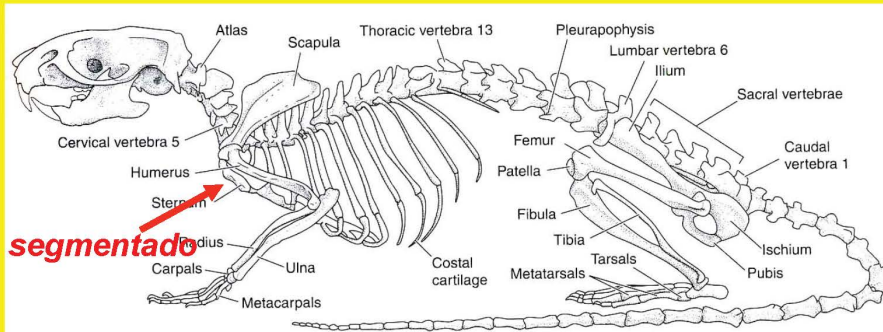


FIGURE 8-18
A lateral view of the skeleton of a rat. (After Hebel and Stromberg.)

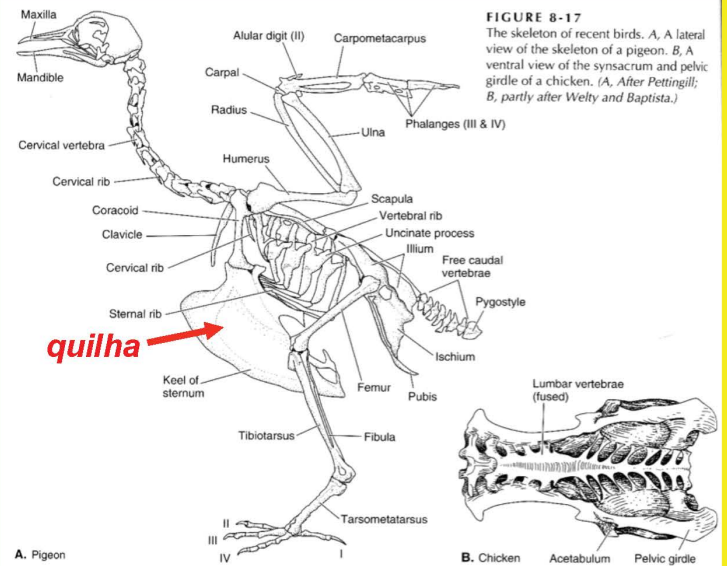
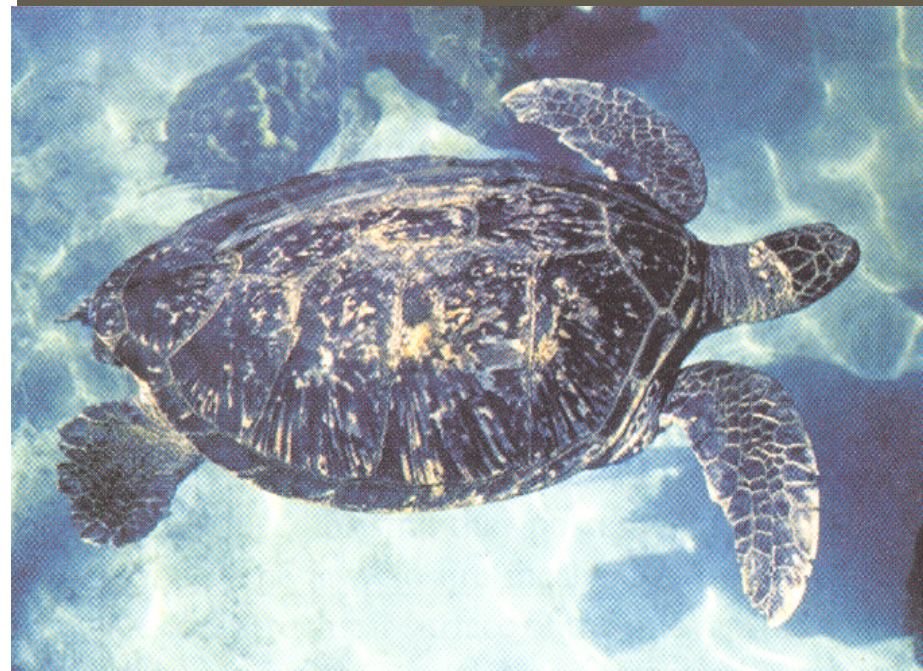
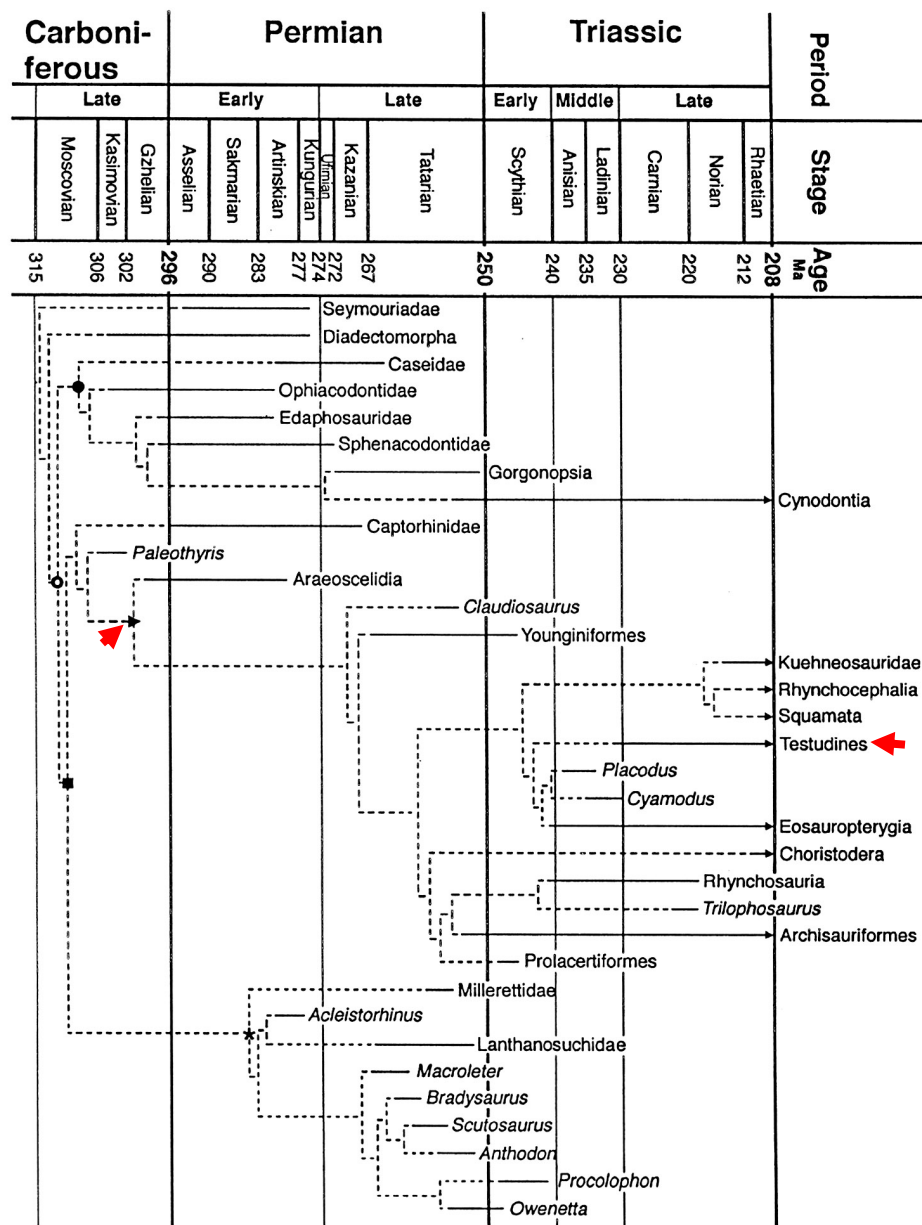


FIGURE 8-17
The skeleton of recent birds. *A*, A lateral view of the skeleton of a pigeon. *B*, A ventral view of the synsacrum and pelvic girdle of a chicken. (*A*, After Pettingill; *B*, partly after Welty and Baptista.)

POSIÇÃO FILOGENÉTICA E DIVERSIDADE DOS TESTUDINES



Intervalo sem fosséis do Carbonífero ao Triássico médio:
Ghost lineage ou origem mais recente?

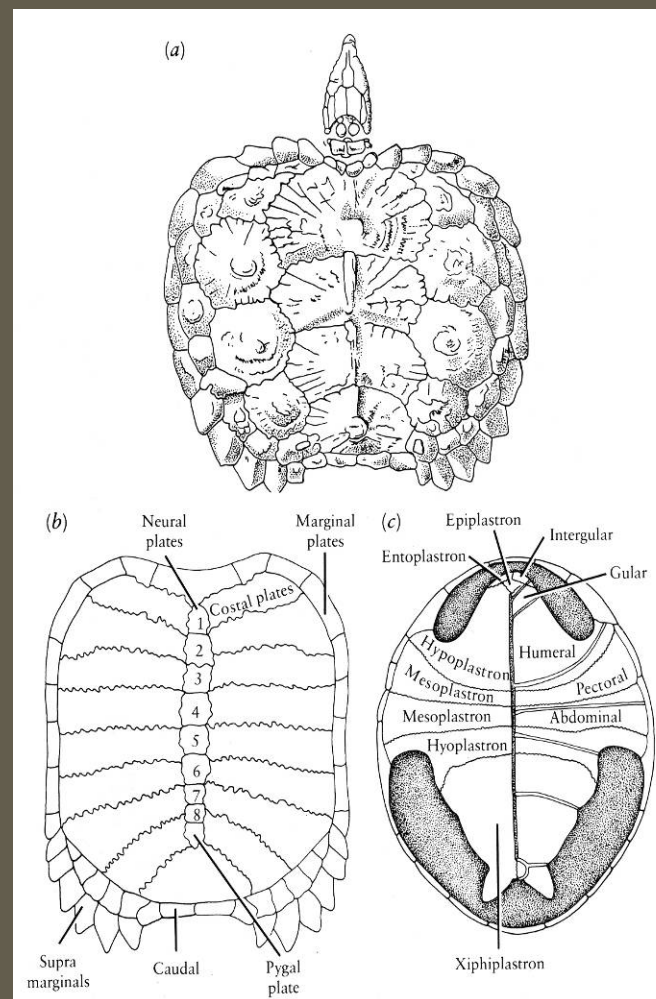


ATARTARUGA MAIS BASAL

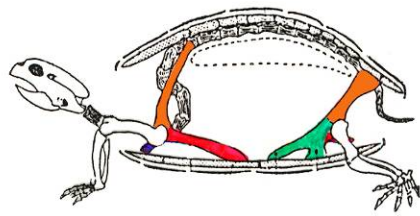
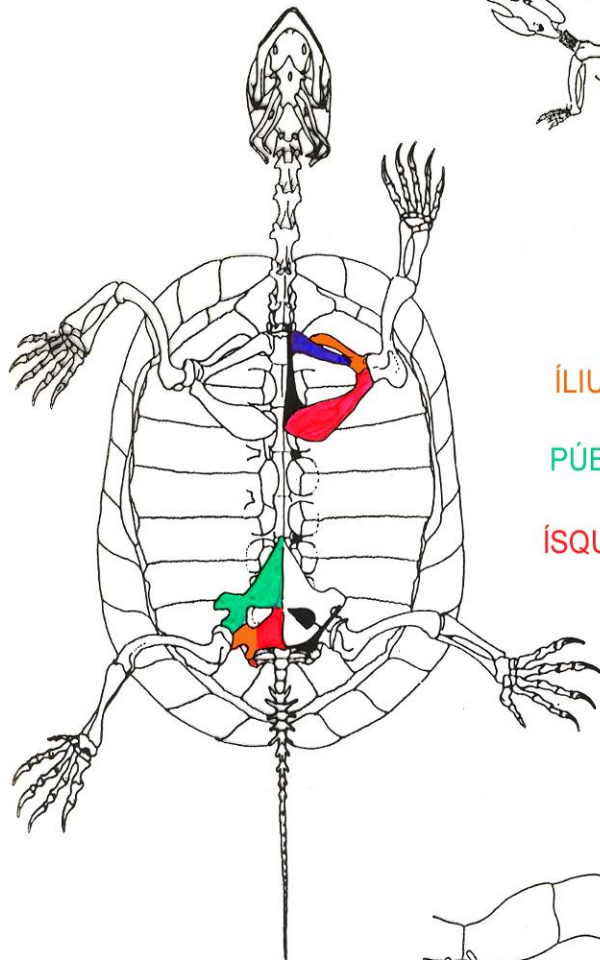
Proganochelys do Triassico Sup. da Alemanha

Uma das tartarugas mais antigas conhecidas e a mais bem preservada

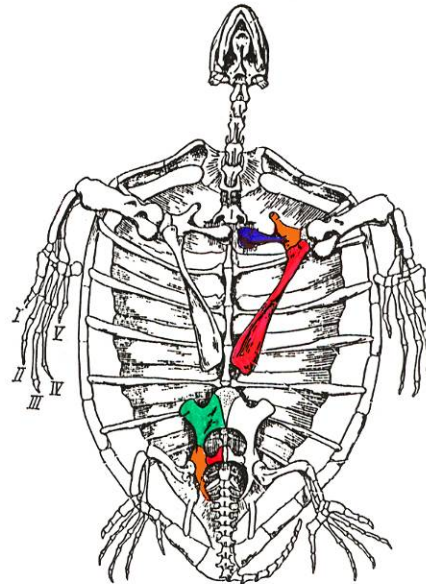
Já apresenta um plano básico típico de Testudines



TERRESTRE



MARINHA



ÍLIUM

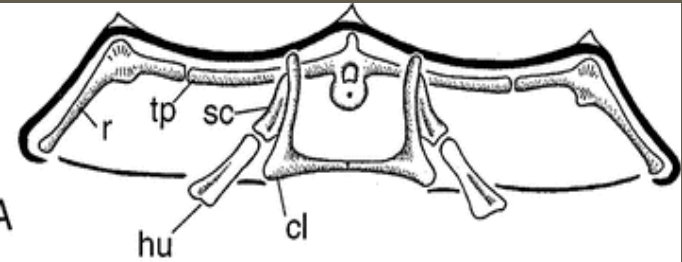
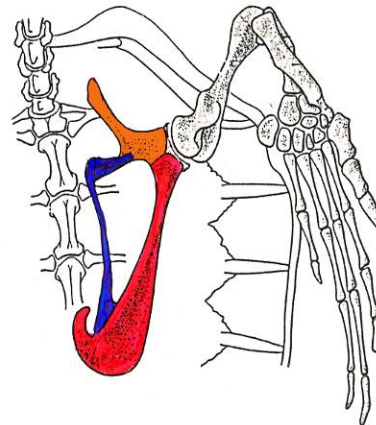
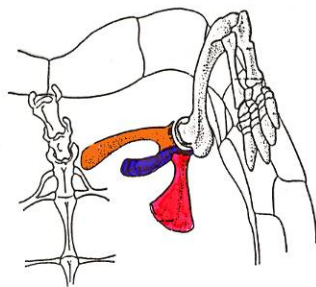
PÚBIS

ÍSQUIO

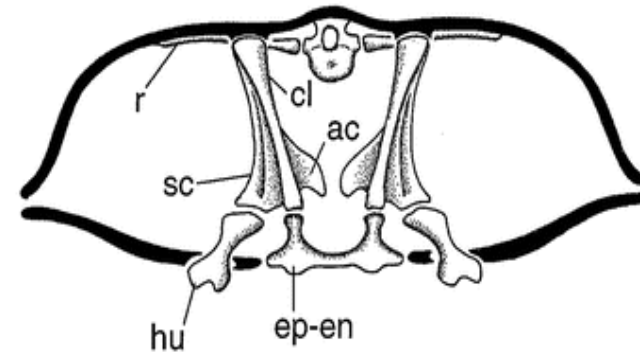
ESCÁPULA

APÓFISE
PRÉ-ESCAPULAR
(ACRÔMIO)

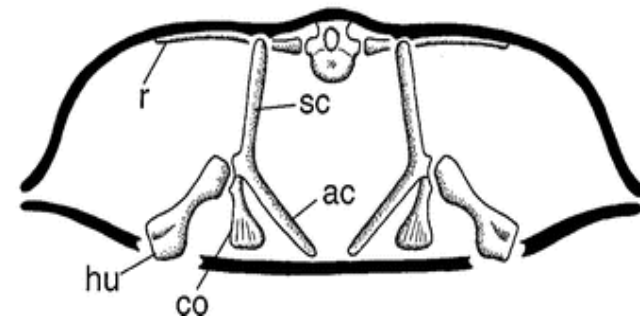
CORACÓIDE



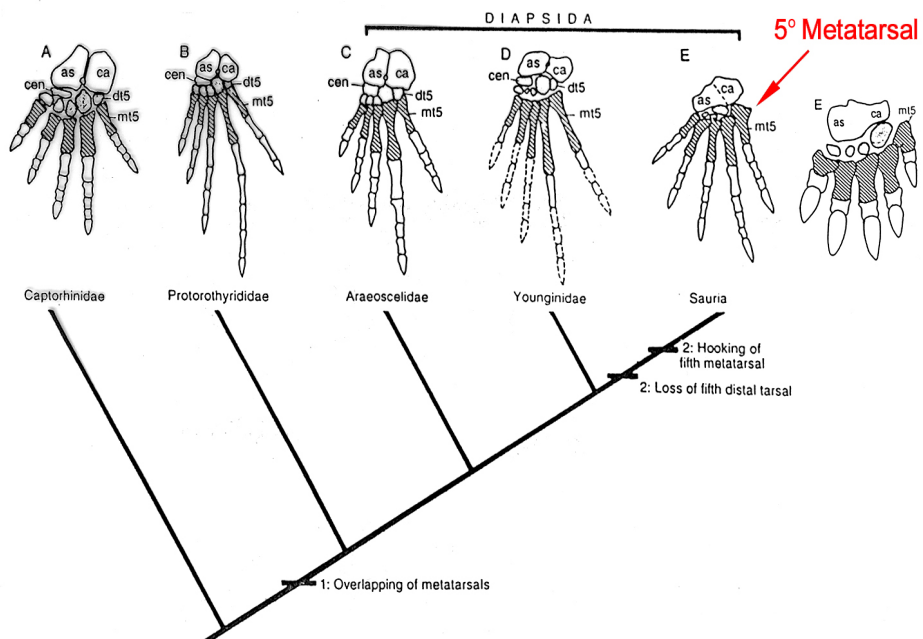
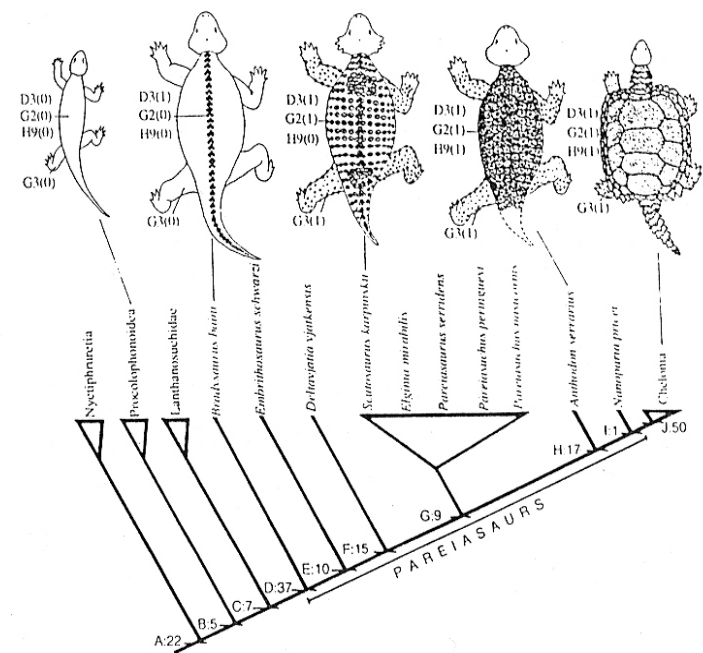
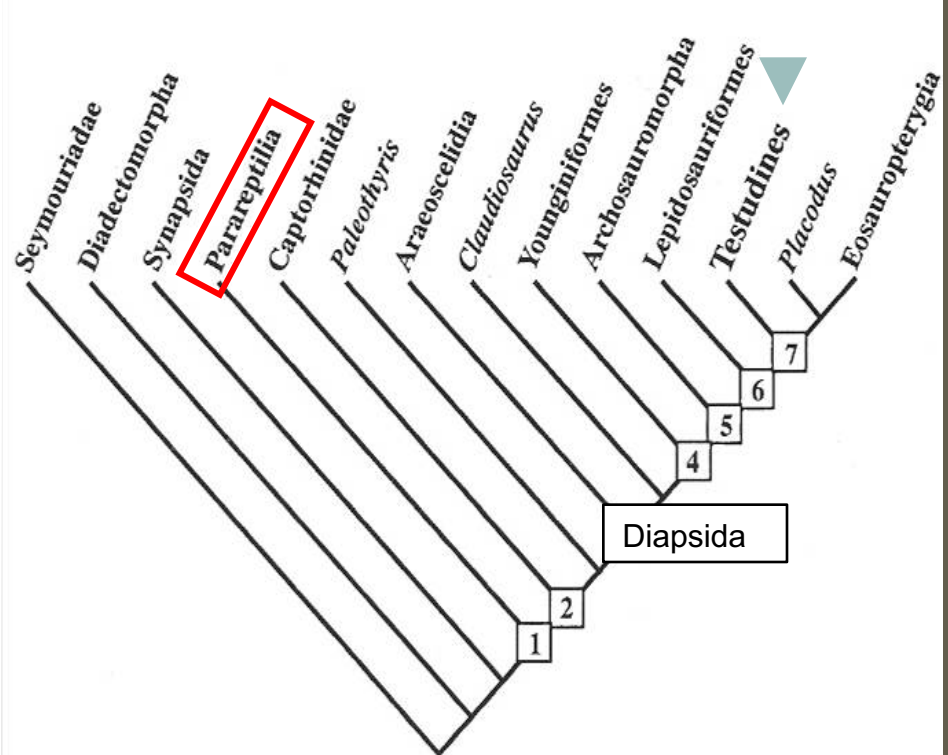
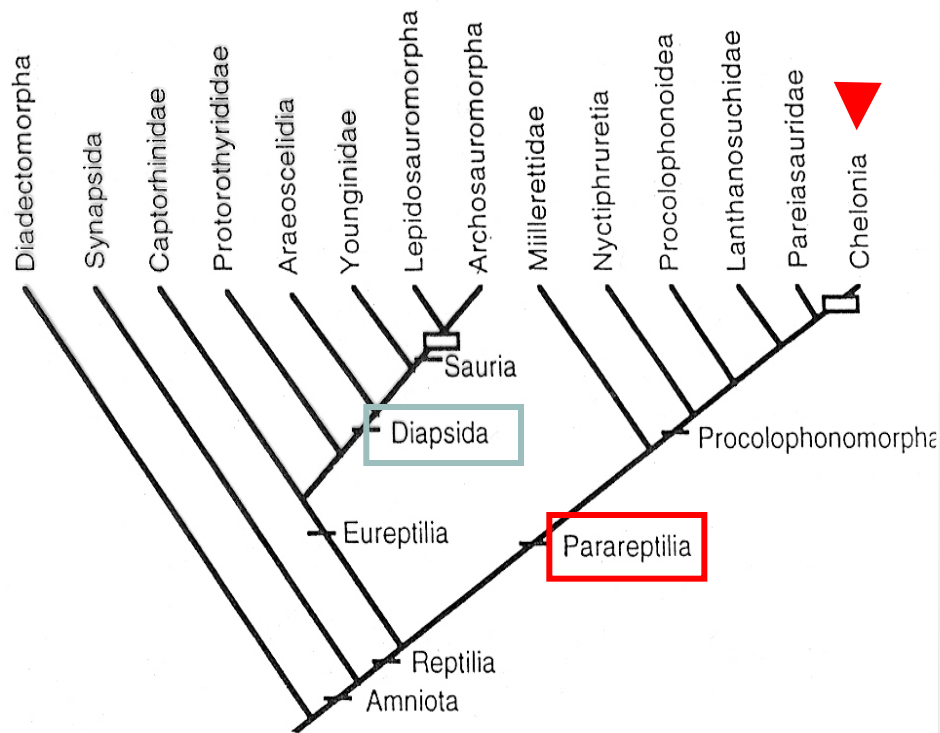
A



B

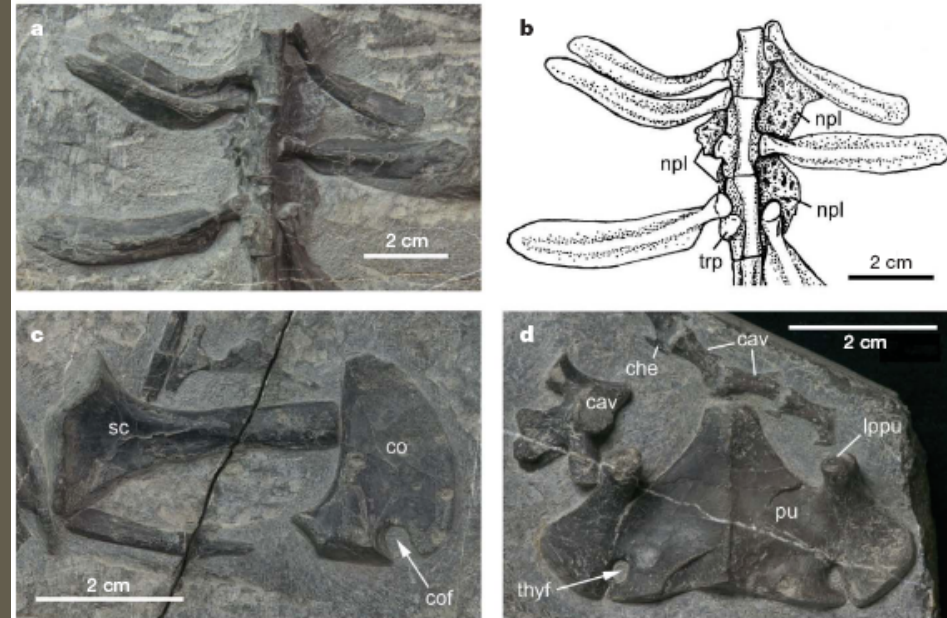
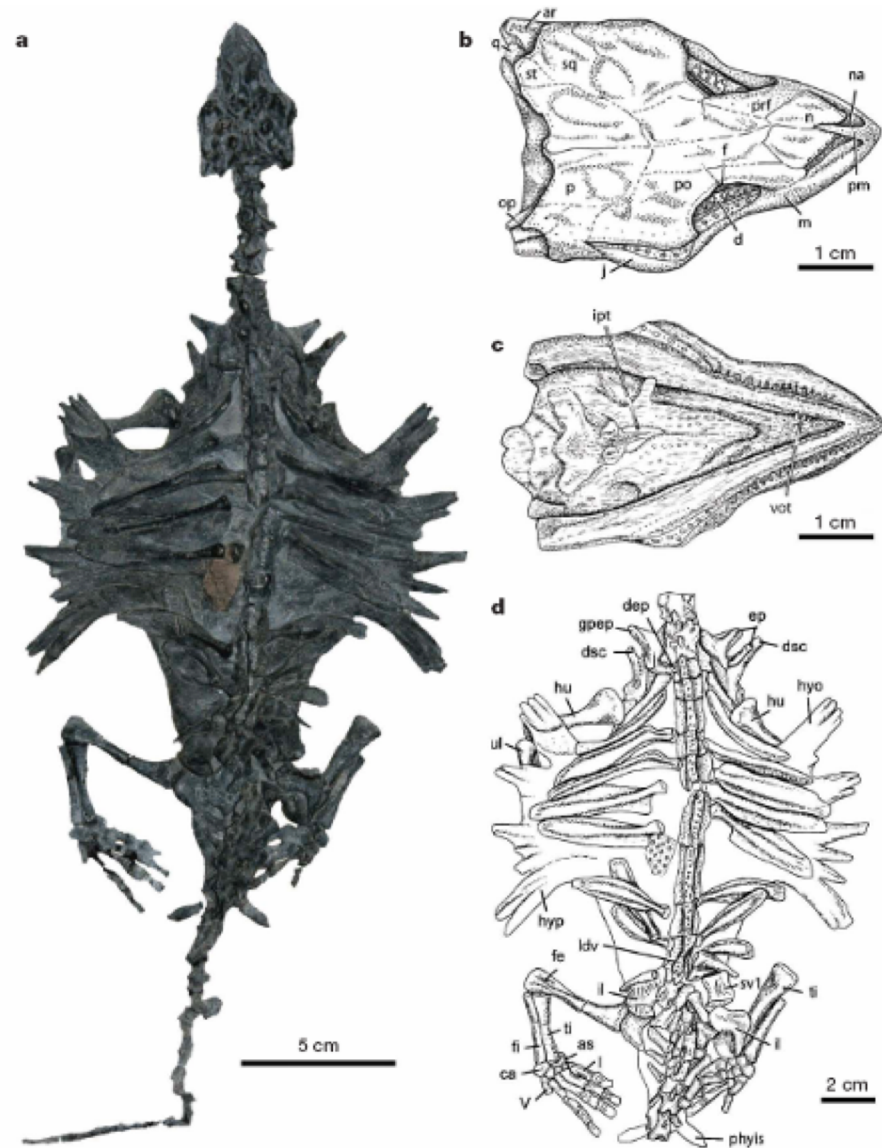
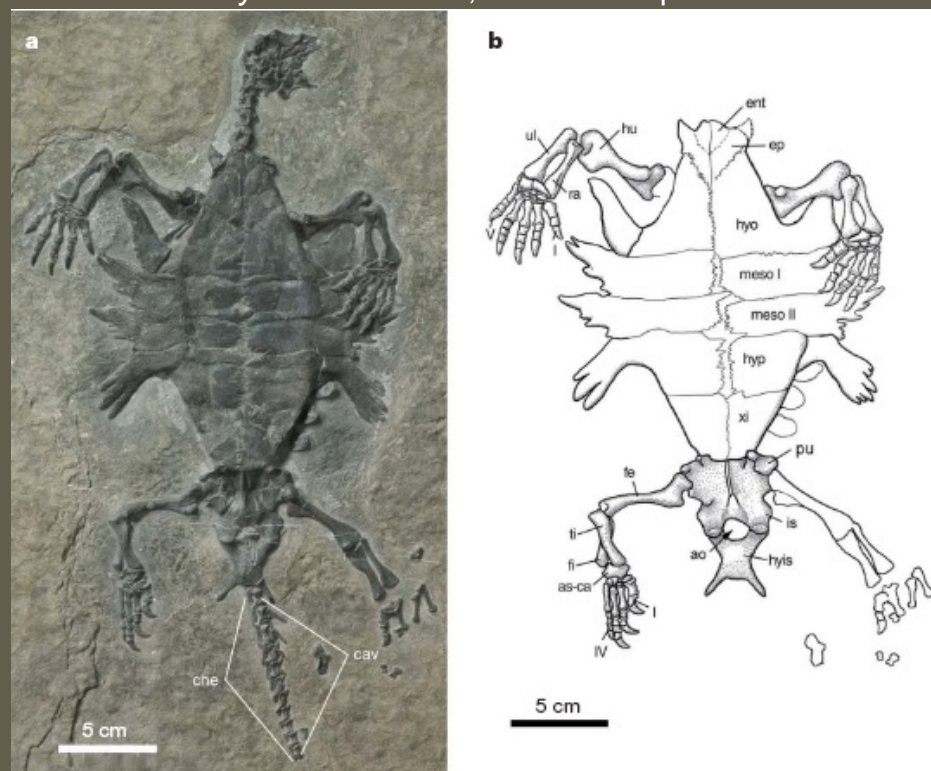


C



LETTERS

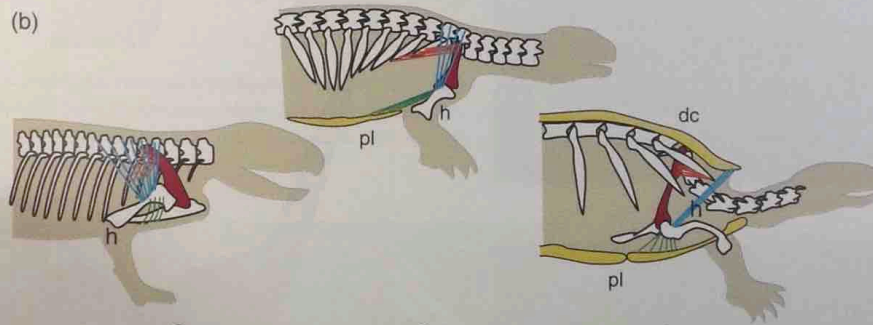
An ancestral turtle from the Late Triassic of southwestern China

*Odontochelys semitestacea*, Triassic Superior da China

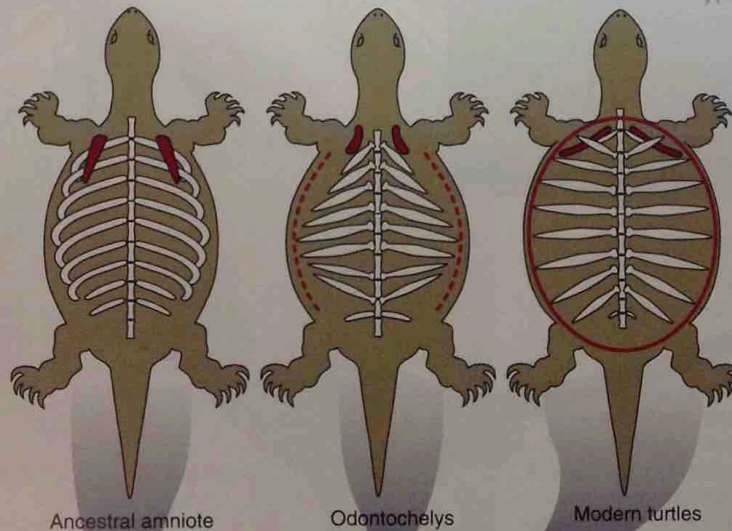
(a)



(b)



(c)



Ancestral amniote

Odontochelys

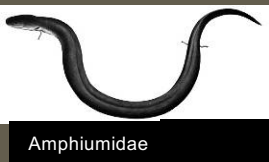
Modern turtles

Axial arrest of the ribs
plastron

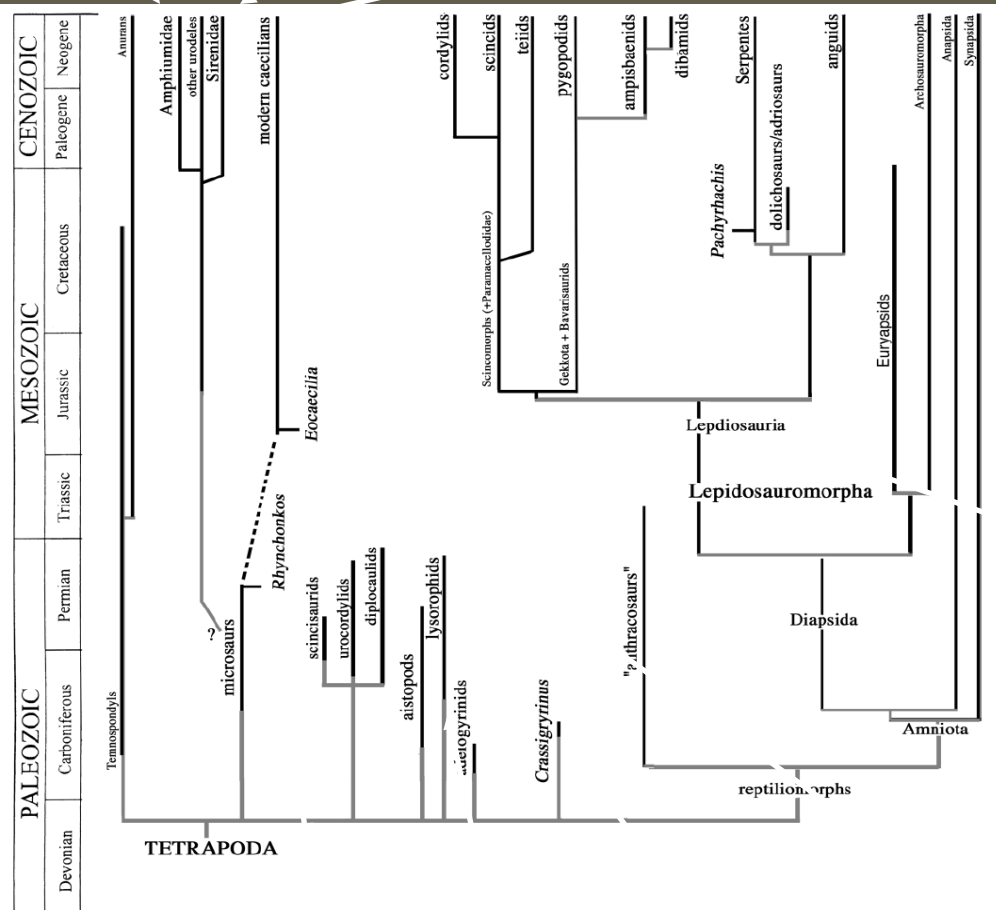
Completion of the CR
Acquisition of the dermal carapace
Fan-shaped growth of the ribs
Encapsulation of the scapula

Odontochelys ilustra transição morfológica importante na serie de transformação que leva à formação da carapaça

escápula internalizada
costelas dissociadas da escápula
costelas achatadas e expandidas lateralmente



MÚLTIPLAS REDUÇÕES DE PATAS E ALONGAMENTO DO CORPO NOS TETRAPODA



SQUAMATA

Redução ou perda de patas observadas em 53 linhagens distintas

AMPHISBAENIA



ANIELLIDAE



ANGUIDAE



SCINCIDAE



DIBAMIDAE



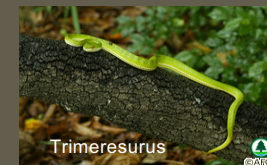
PYGOPODIDAE



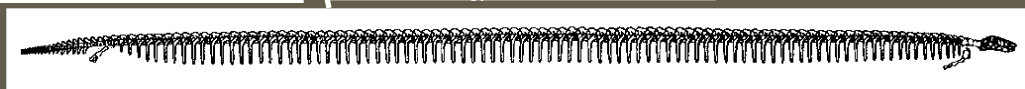
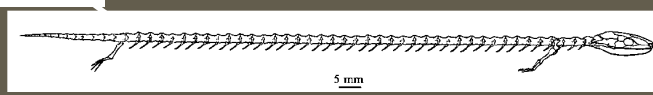
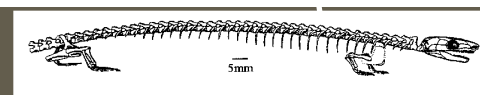
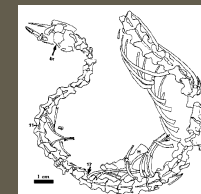
GYMNOPHTHALMIDAE



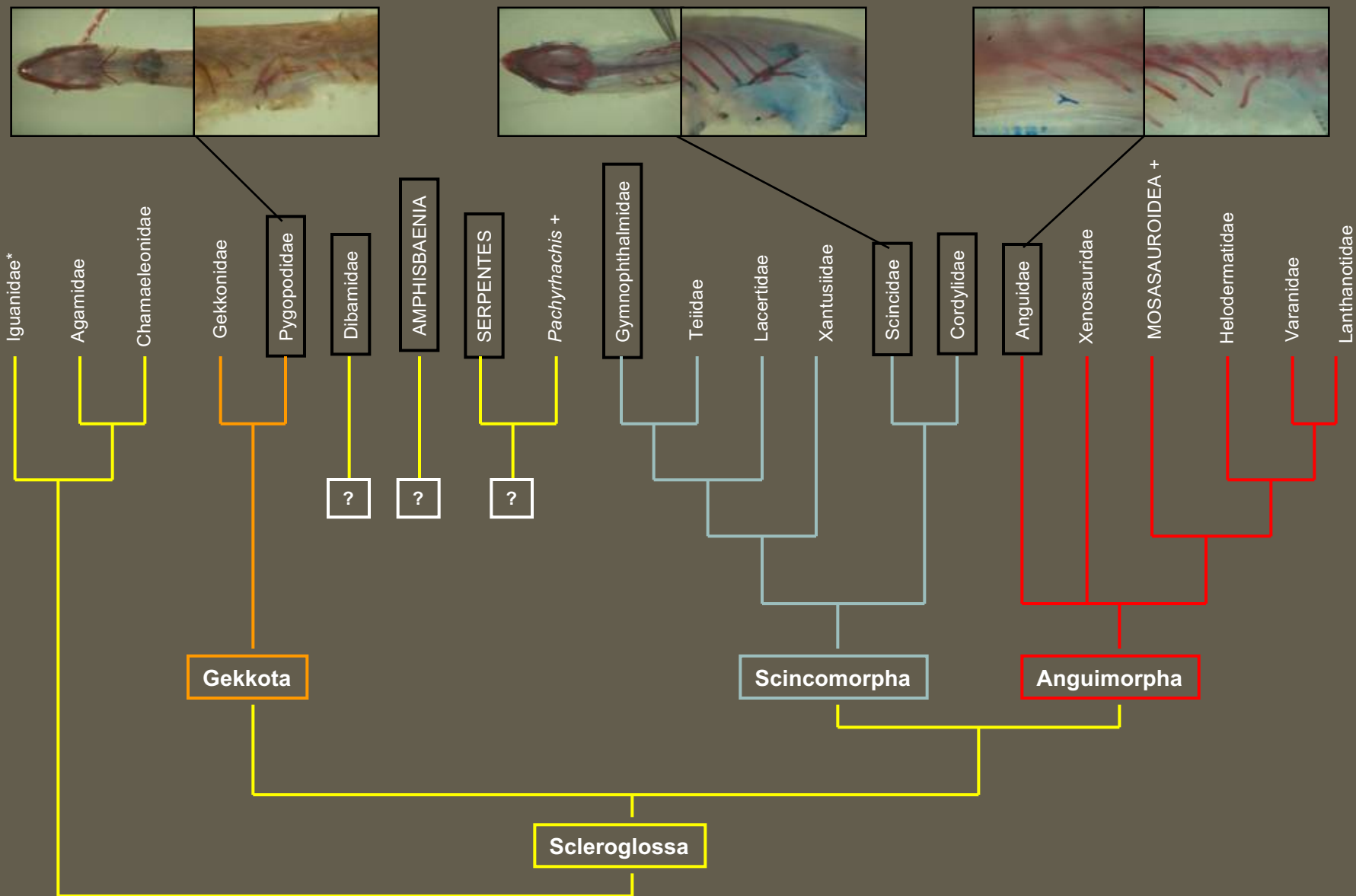
SERPENTES



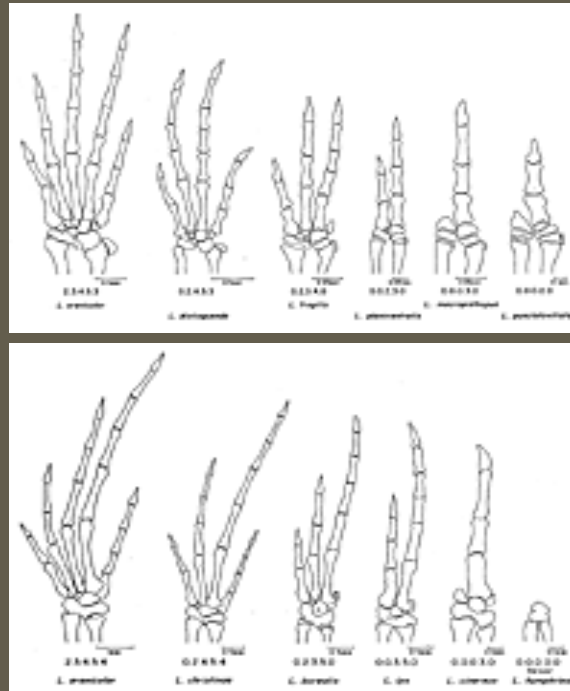
DOLICHOSAURIA



A redução e perda das patas traseiras nos Squamata se deve geralmente à perda da crista apical, estrutura embriológica presente no broto do membro e responsável pelo estímulo de suas células formadoras.

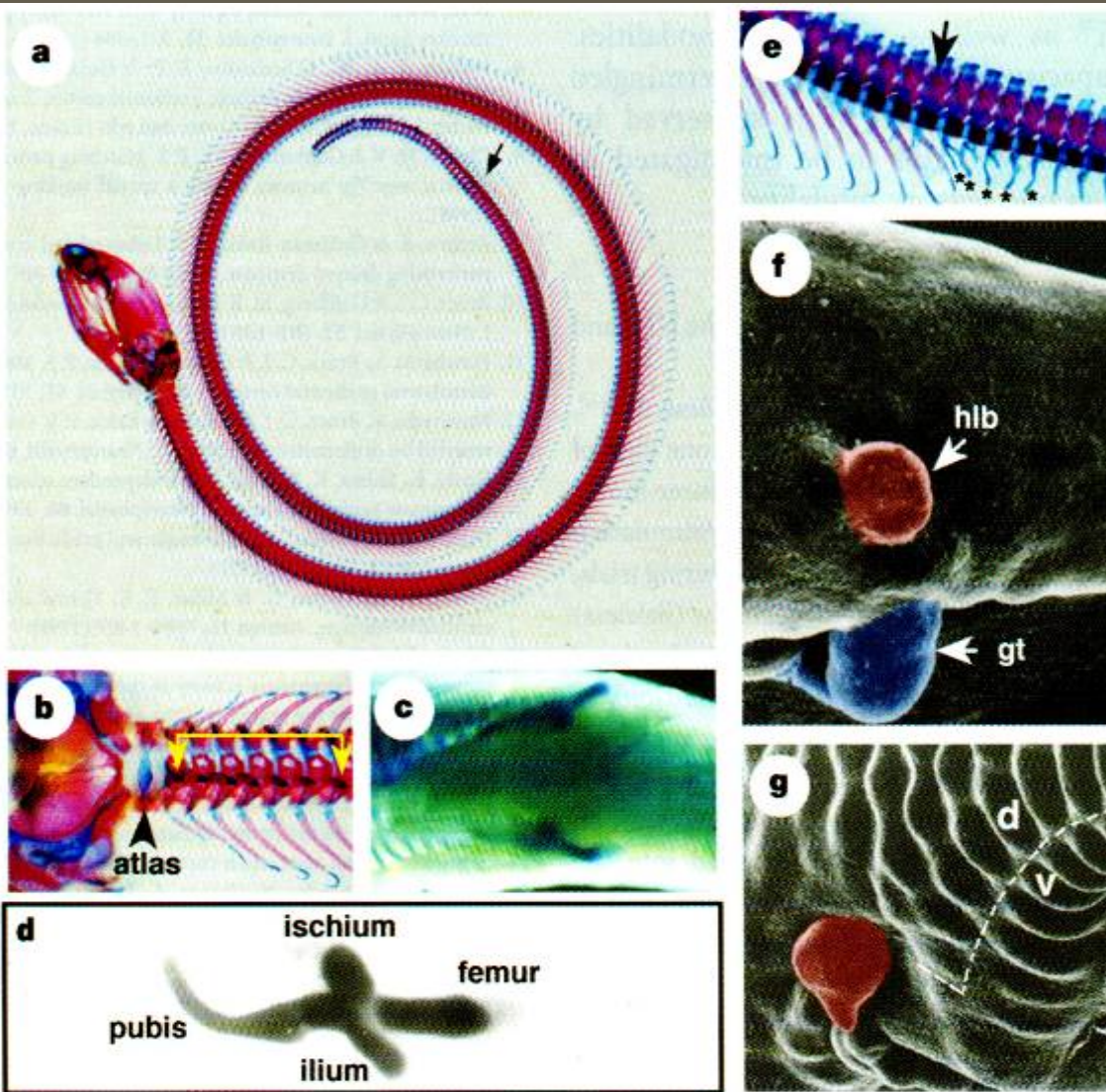


O gênero *Lerista* de scincídeo: um exemplo de evolução para a condição serpentiforme



São todos lagartos psamófilos, isto é, adaptados à vida em um substrato arenoso !!

A perda das patas nas Serpentes

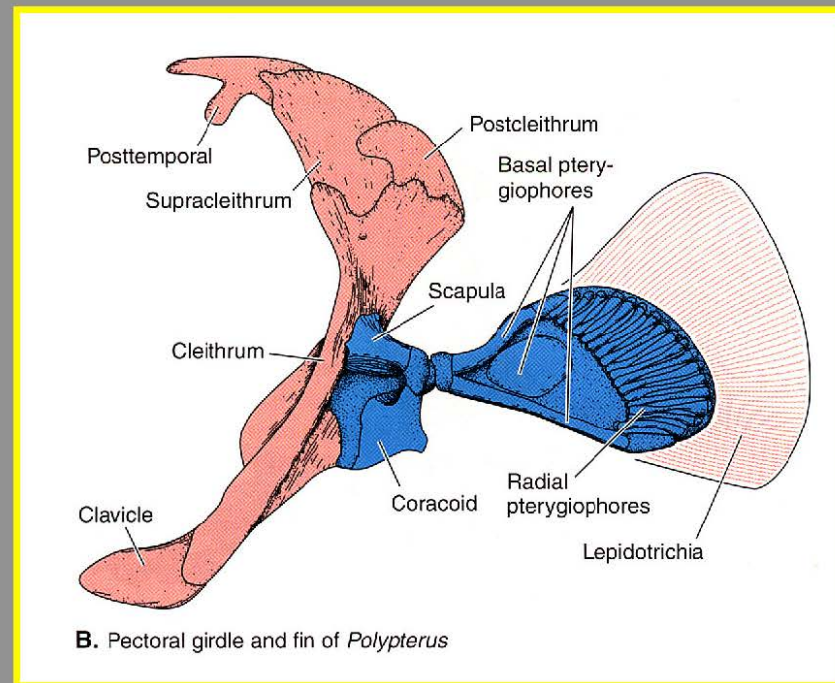
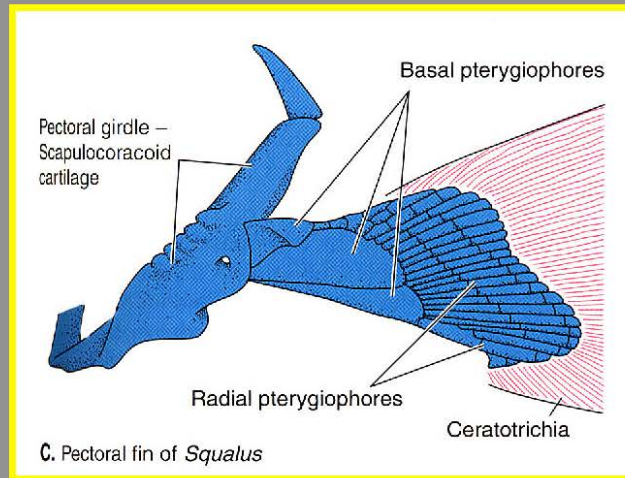


O aumento da região de expressão do gene Hox responsável pela formação do tórax no domínio do pescoço das serpentes conduziu ao “desligamento” do gene Hox com influência no pescoço e, como consequência, na perda da cintura escapular e das patas dianteiras.

A redução à vestígios das patas traseiras é uma consequência da perda de uma estrutura embriológica, a crista apical, não tendo um efeito dramático na expressão dos genes Hox associados à formação dos membros posteriores. Por esta razão, a maioria das serpentes mantêm patas traseiras vestigiais

cintura peitoral

Esqueleto Apendicular



Esqueleto Apendicular

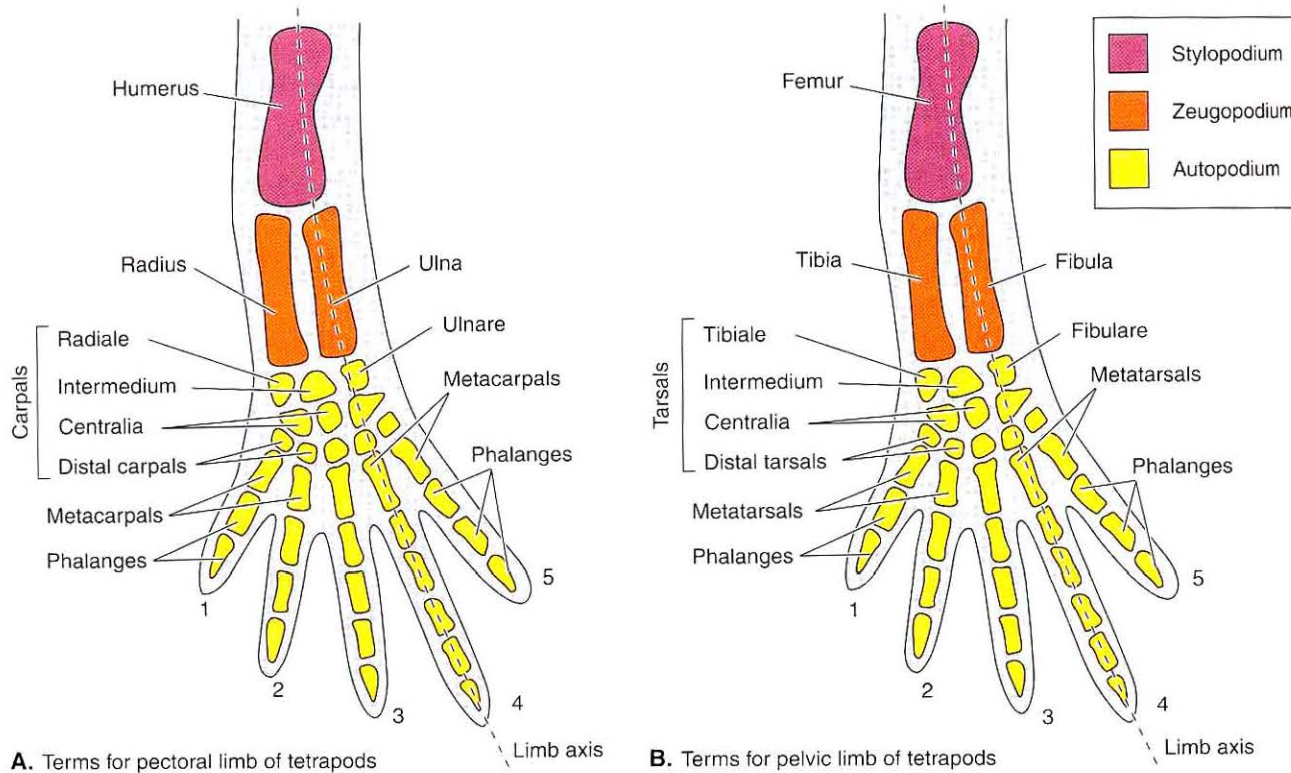


FIGURE 9-7

Diagrams of a generalized five-digit cheiropterygium of a tetrapod, showing terms used for elements in the pectoral (A) and pelvic (B) appendages. Note that the limb axis extends along the posterior border of the limb and into the fourth digit.

Formação do esqueleto: Apendicular

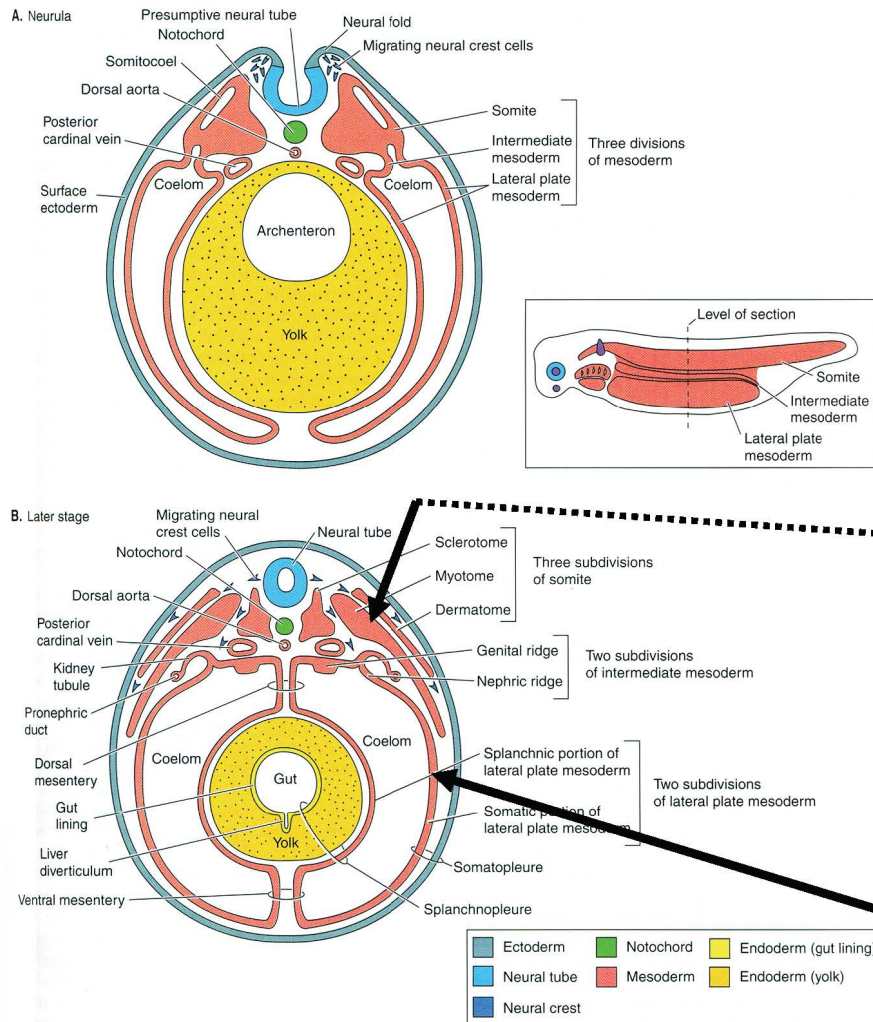
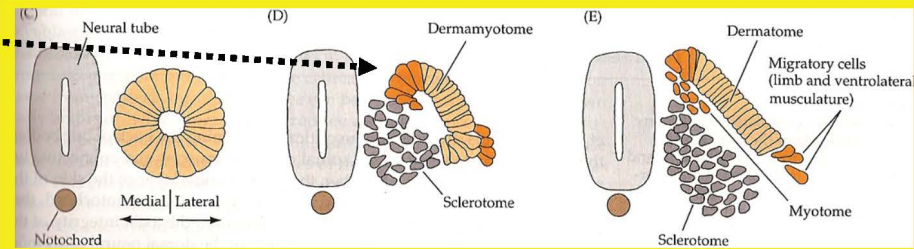
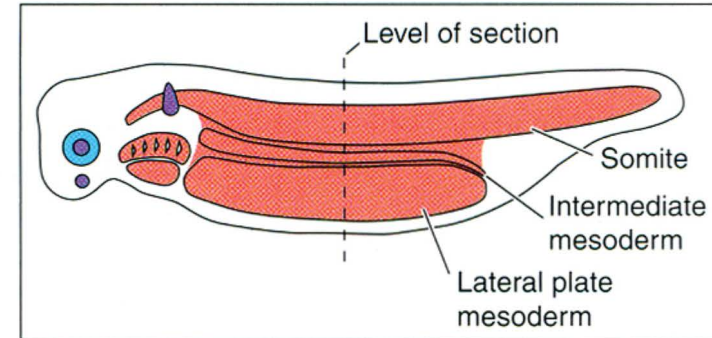


FIGURE 4-16
Differentiation of trunk mesoderm in an idealized amphibian embryo. **A.** Early neurula. The inset shows a lateral view and the plane of section for the figure in **A.** It also diagrams the basic organization of the three divisions of trunk mesoderm. In amphibian embryos (and other vertebrates with mesolecithal eggs) the moderate amount of yolk is incorporated into yolk-laden cells in the floor of the archenteron. **B.** Later neurula, showing the structures that develop from each somite and each germ layer. Note that each of the three divisions of trunk mesoderm diagrammed in **A.** in turn gives rise to subdivisions. See text for additional descriptions.

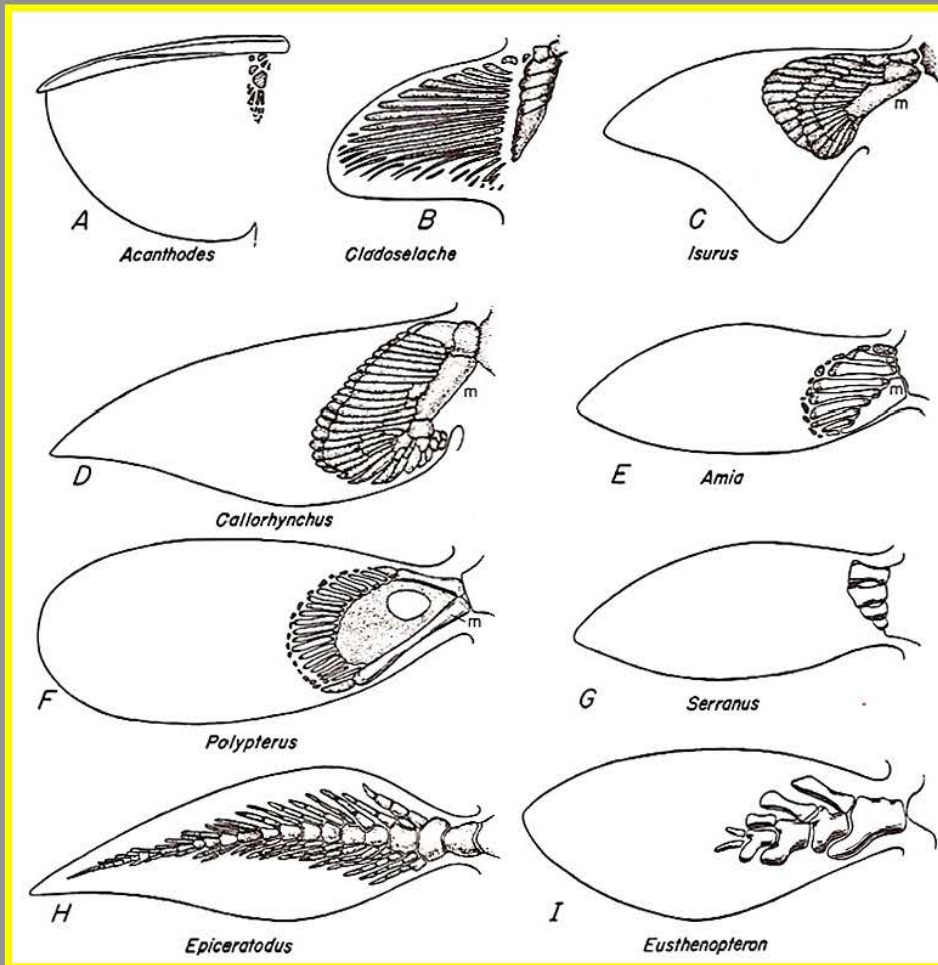


-musculatura apendicular:
origem do miótomo

-esqueleto apendicular:
origem do hipômero
(mesoderma de placa lateral)

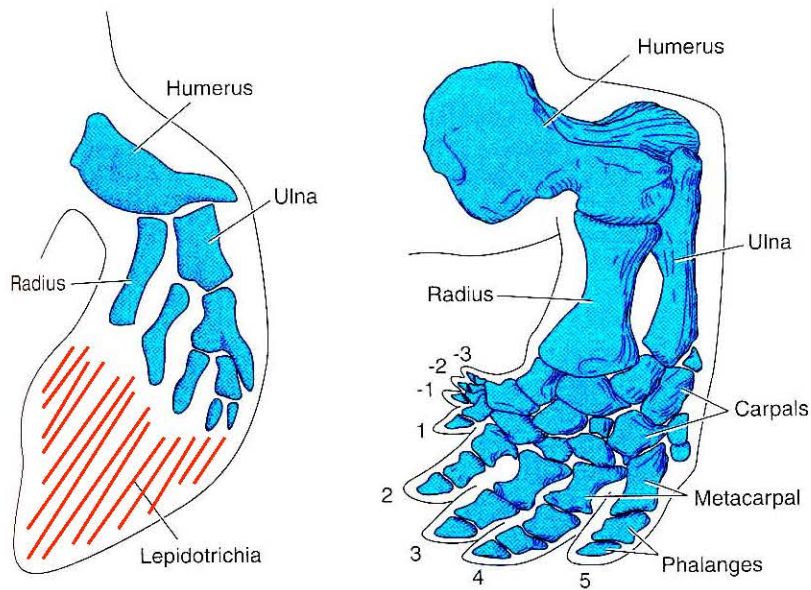
Esqueleto Apendicular

nadadeira peitoral



Esqueleto Apendicular

osteolepiforme → tetrápode



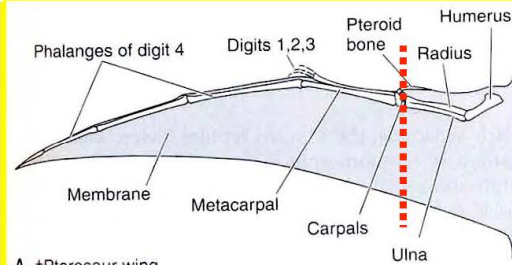
A. Pectoral fin of †*Eusthenopteron*

B. Pectoral limb of †*Acanthostega*

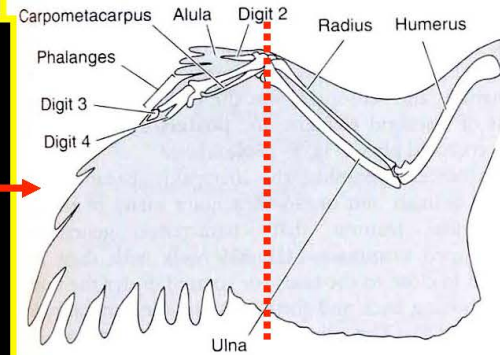
FIGURE 9-8

Changes in the pectoral appendage during the transition from water to land. A, The crossopterygium fin of a choanate fish. B, The limb of an early tetrapod (an †*a*canthostegid).

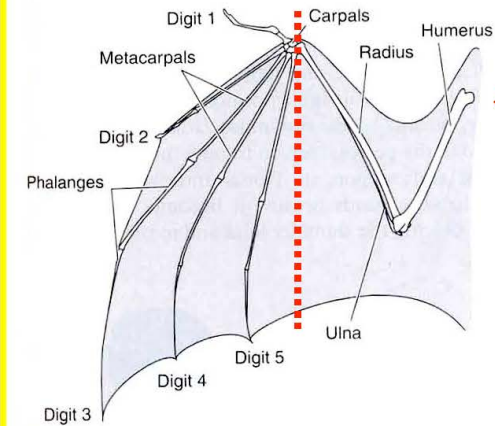
Esqueleto Apendicular



A. †Pterosaur wing

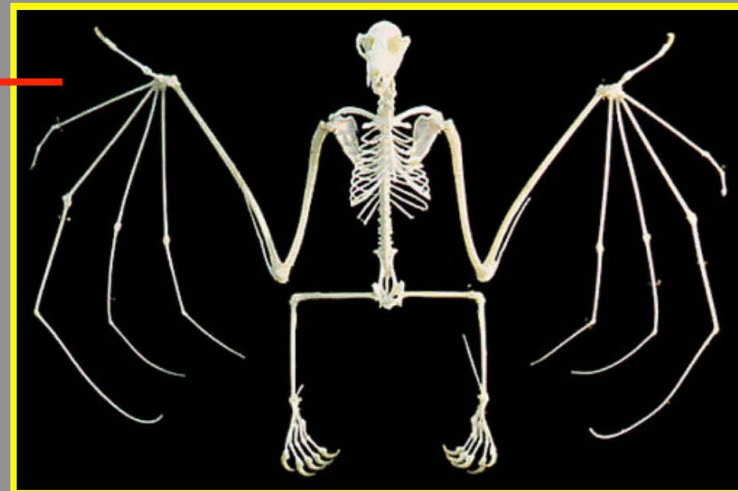
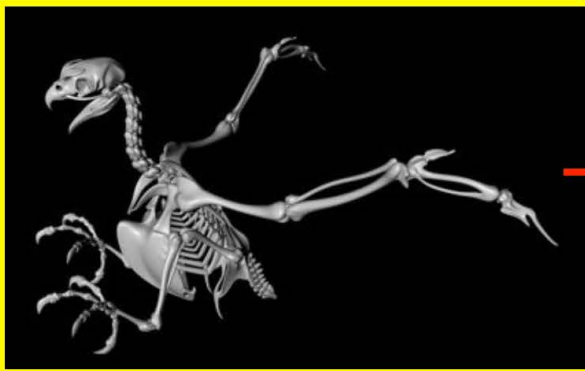


B. Bird wing



C. Bat wing

FIGURE 9-12
A-C, Dorsal views of extended vertebrate wings. (After Norberg.)



Esqueleto Apendicular

retorno à água

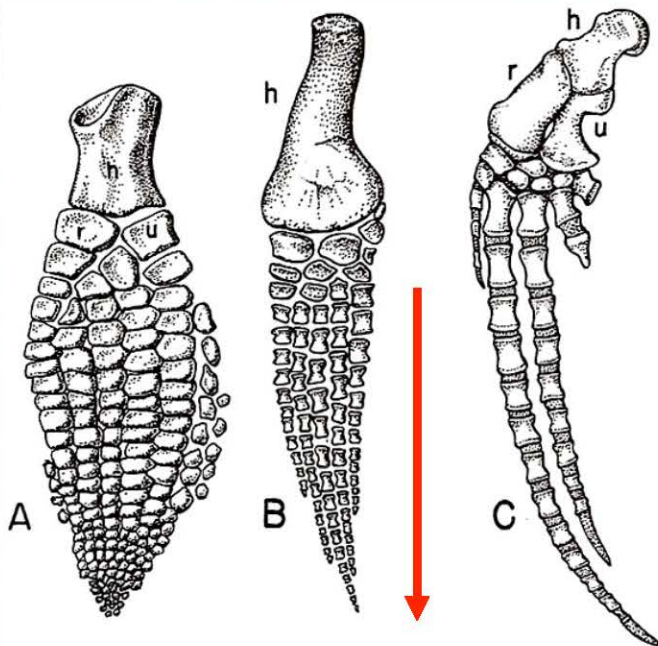
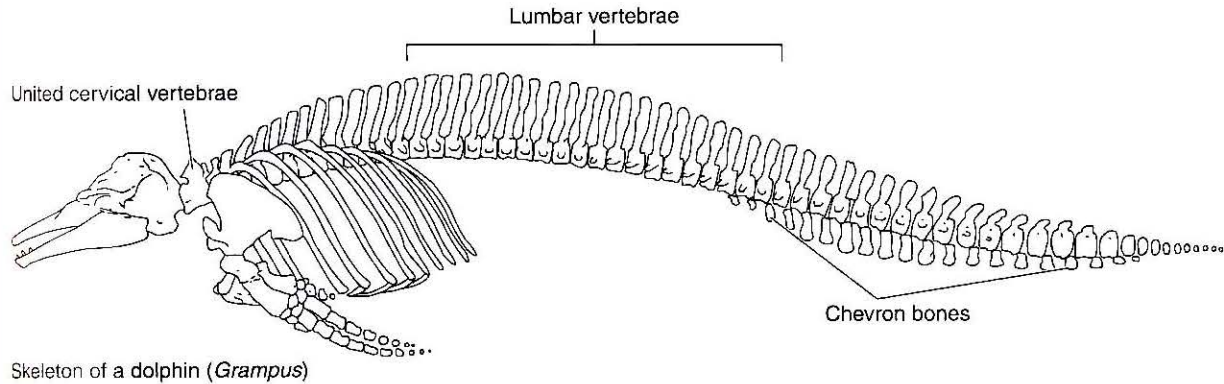


Fig. 134. Examples of tetrapod appendages retransformed into fishlike paddles in marine forms. Pectoral limbs of *A*, an ichthyosaur; *B*, a plesiosaur; *C*, a whale. In all there has been a shortening and broadening of the proximal bones and a multiplication of the phalanges. *h*, Humerus; *r*, radius; *u*, ulna. (*A* after Huene; *B* after Williston; *C* after Flower.)

multiplicação das falanges

Esqueleto Apendicular

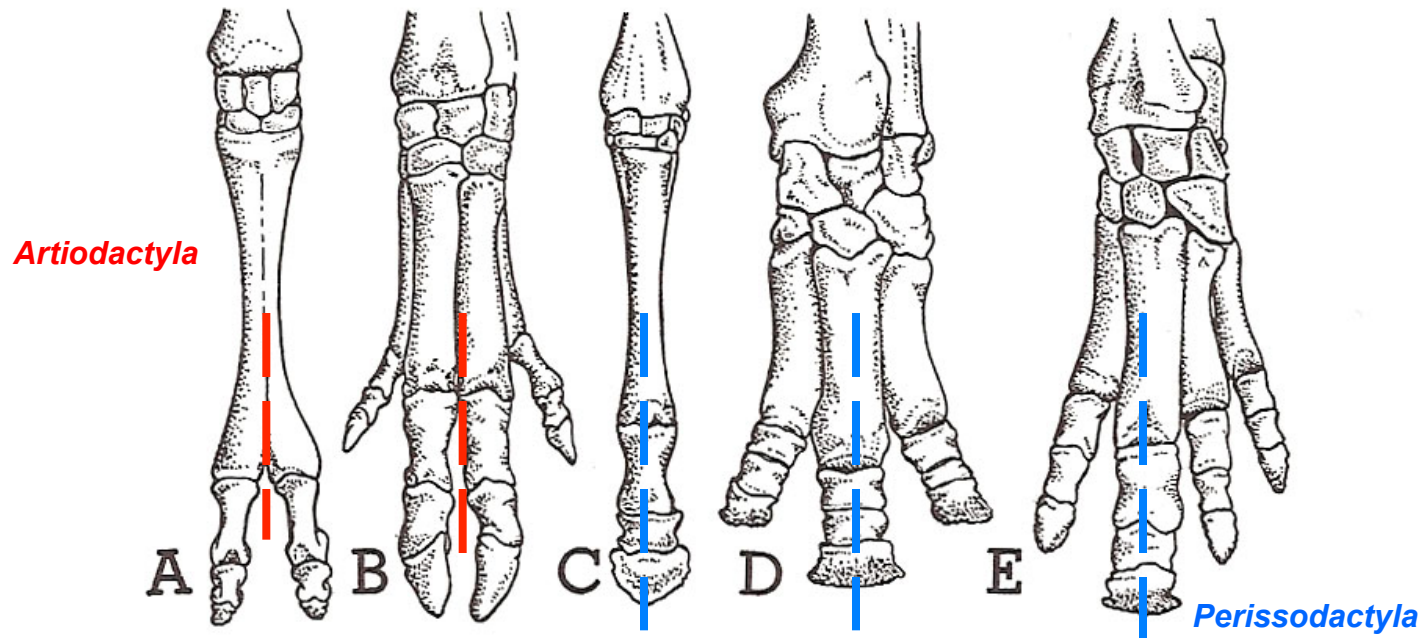


Fig. 141. Left front feet of ungulates—in order, camel, pig, horse, rhinoceros, and tapir. The first two are artiodactyls, in which the axis of symmetry lies between the third and fourth toes. In the pig (B) lateral toes, 2 and 5, are complete but small. In most artiodactyls, as in the camel (A), the two main metapodials are fused into a cannon bone. The three remaining forms are perissodactyls, in which the axis runs through the third toe. In the tapir (E) the pollex is lost, but the other four toes remain; in modern rhinoceroses (D) the fifth toe has disappeared; in modern horses (C) the second and fourth are reduced to splints. (After Flower.)

-ungulígrados: andam sobre as unhas, contrastando com plantígrados e digitígrados

Esqueleto Apendicular

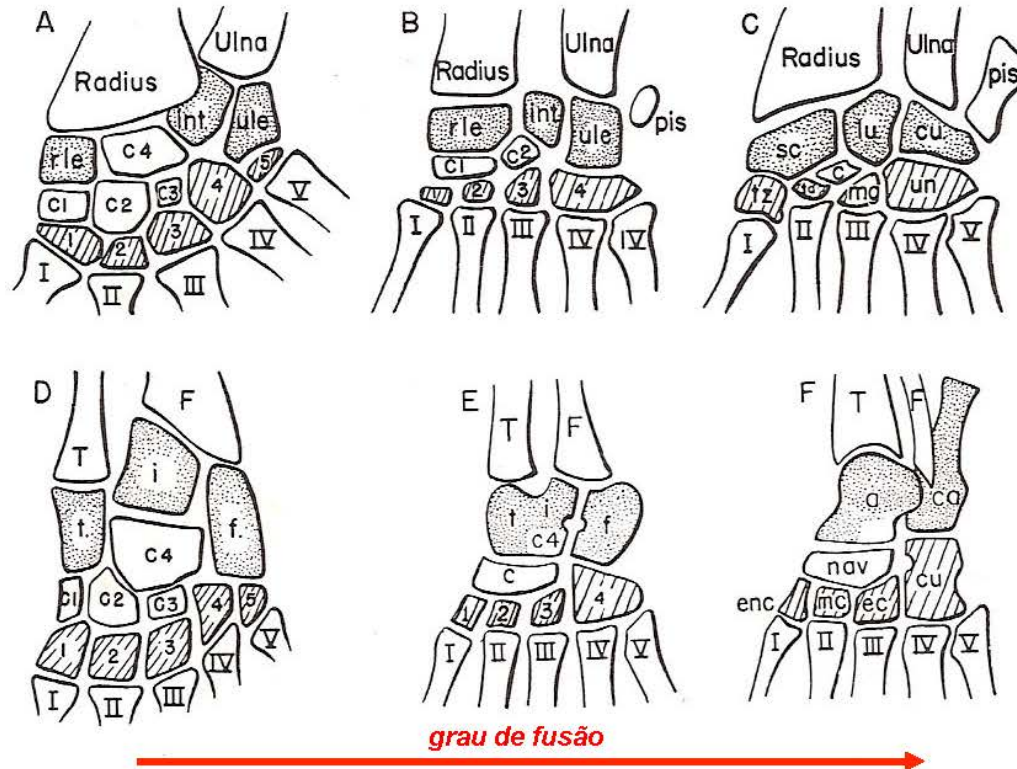


Fig. 140. Diagram of carpus (A to C) and tarsus (D to F) to show essential homologies between primitive tetrapod (A, D), primitive reptile (B, E), and mammal (C, F). Proximal row of elements stippled; central row (and pisiform) unshaded; distal row hatched. Digits indicated by Roman numerals; distal carpals and tarsals by Arabic numerals. *a*, Astragalus; *c*, *c1* to *c4*, centralia; *ca*, calcaneum; *cu*, cuneiform in carpus, cuboid in tarsus; *ec*, external cuneiform (ectocuneiform); *enc*, internal cuneiform (entocuneiform); *f*, fibulare; *F*, *Fib*, fibula; *i*, *int*, intermedium; *lu*, lunar; *mc*, middle cuneiform (mesocuneiform); *mg*, magnum; *nav*, navicular; *pis*, pisiform; *rle*, radiale; *sc*, scaphoid; *t*, tibiale; *T*, *Tib*, tibia; *td*, trapezoid; *tz*, trapezium; *ule*, ulnare; *un*, unciform.

cintura pélvica

Esqueleto Apendicular

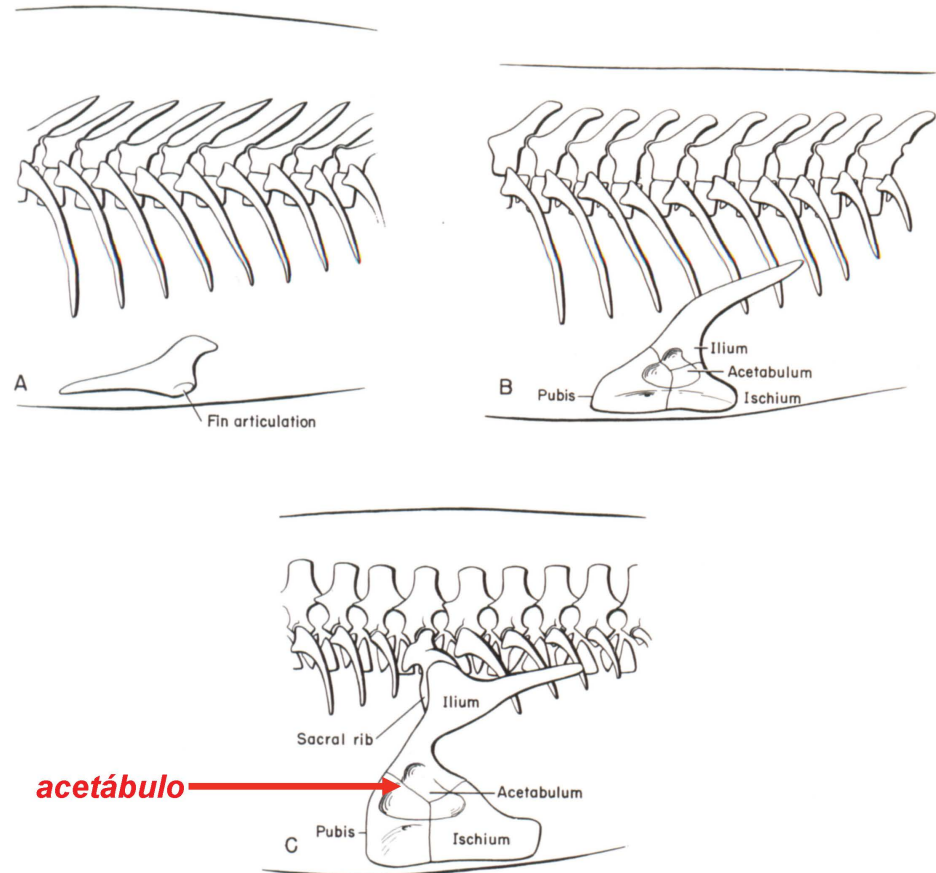
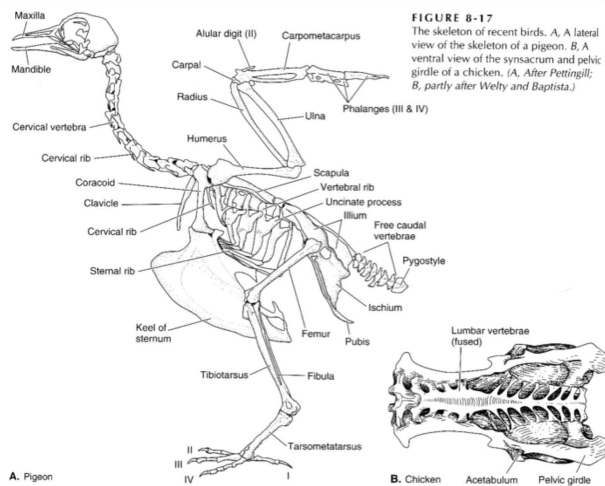
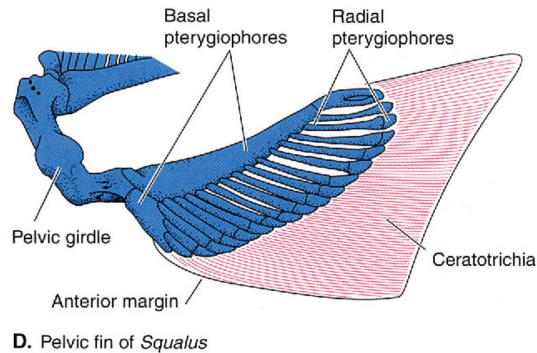
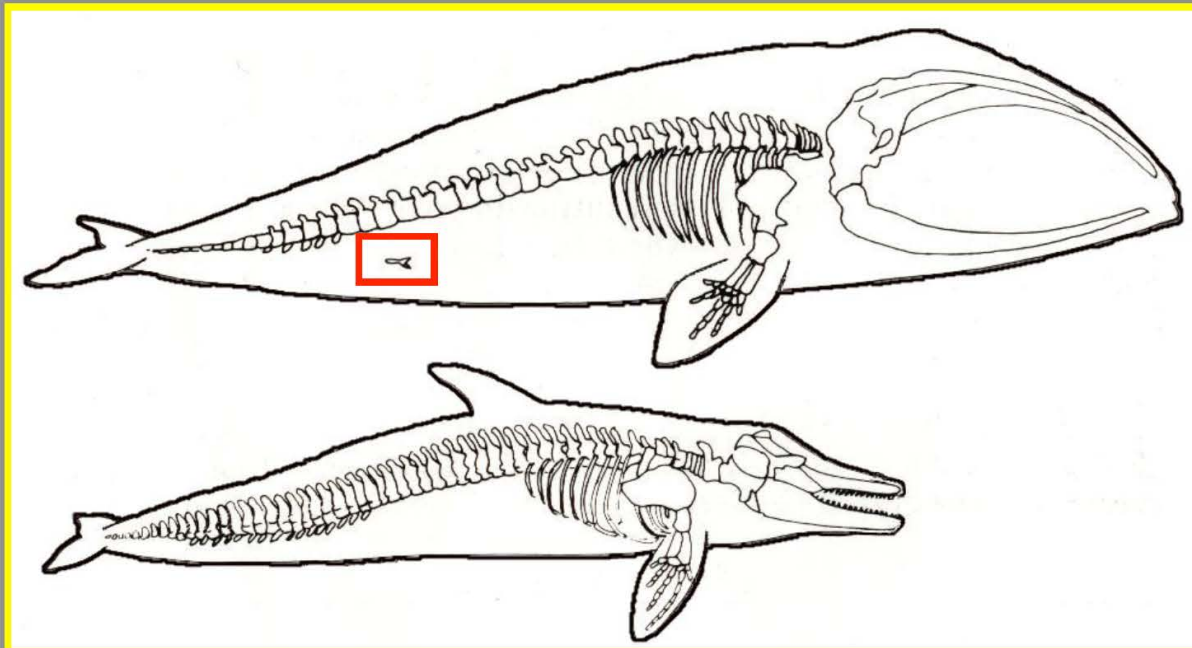
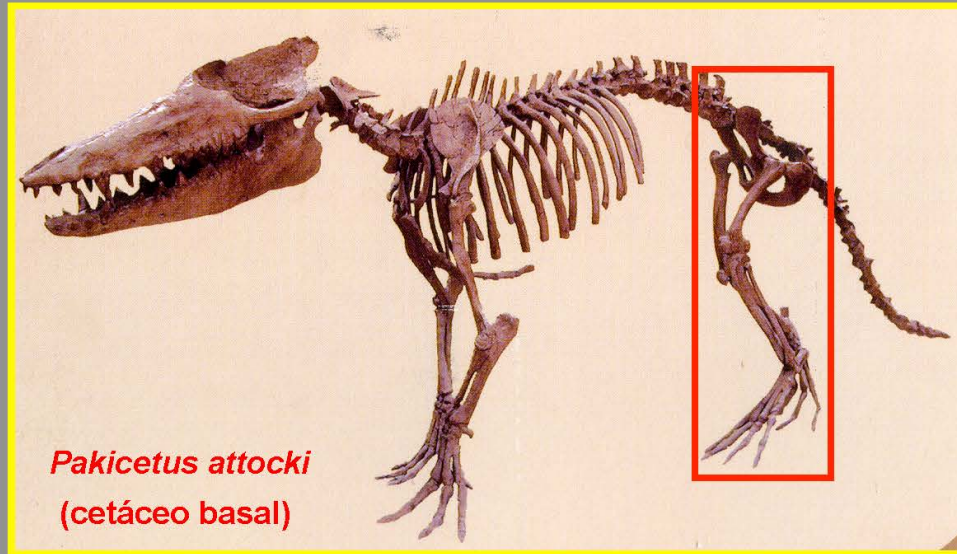


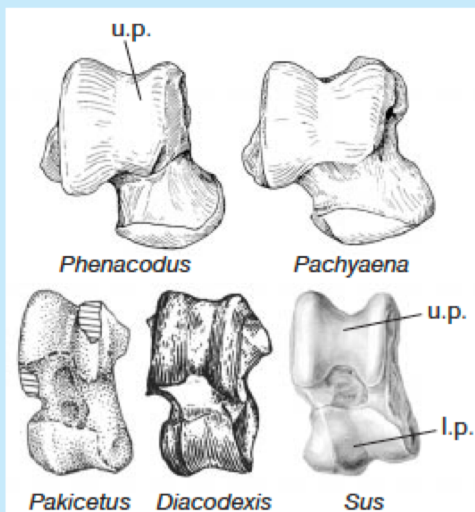
Fig. 125. Diagrams to show the development of the pelvic girdle and sacrum in the evolution of amphibians from fishes. A, Left lateral view of the pelvic region of a fish, with the vertebral column and ribs above, the small pelvic girdle placed ventrally. B, Primitive tetrapod stage, found in some early fossil amphibians. The girdle has expanded, with the three typical bony elements. The ilium extends upward, but was presumably connected with the column only through ligaments binding it to the neighboring ribs. C, The girdle has grown further, and the ilium is firmly attached to an enlarged sacral rib.

cintura p lvica

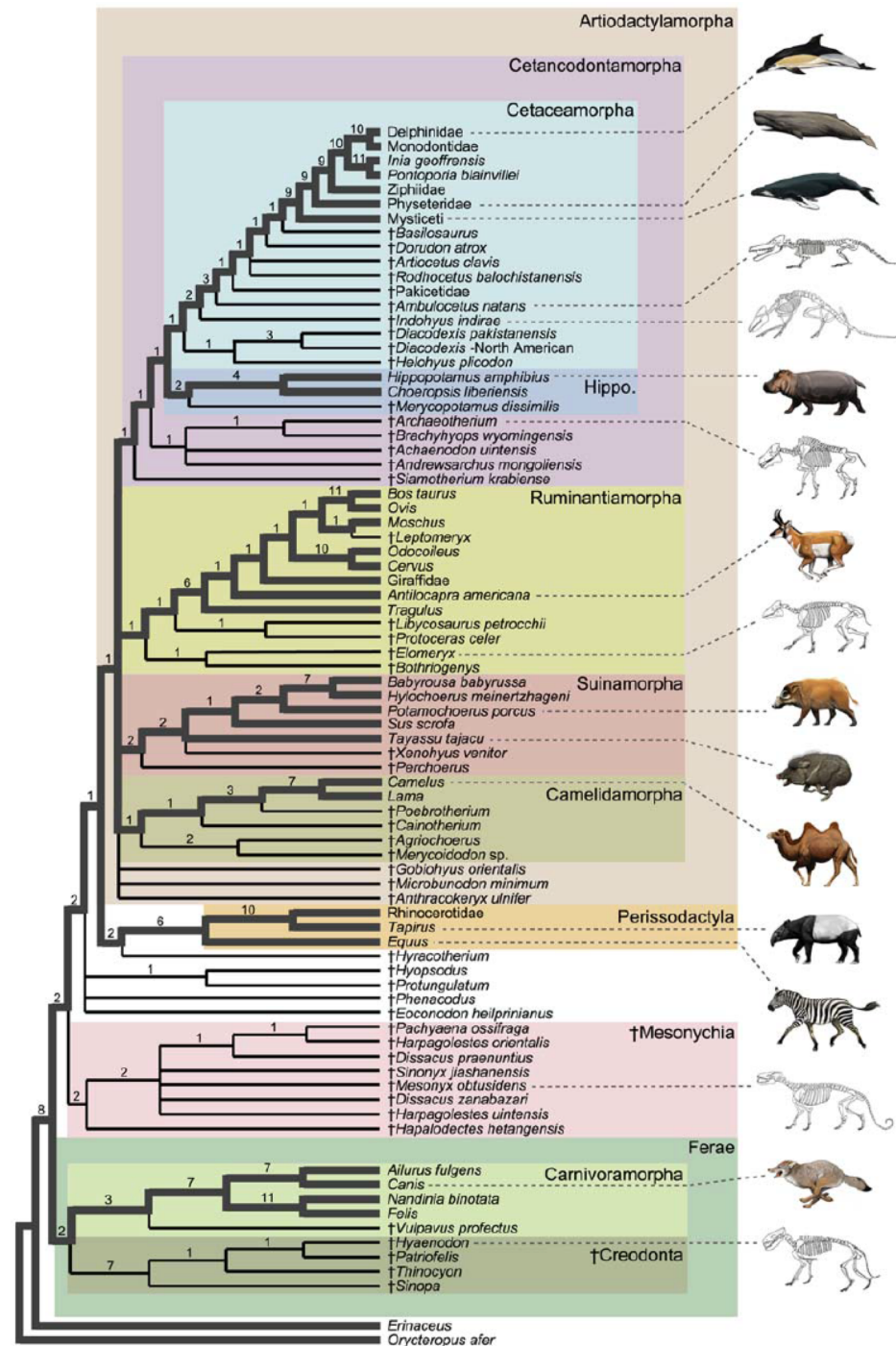
Esqueleto Apendicular



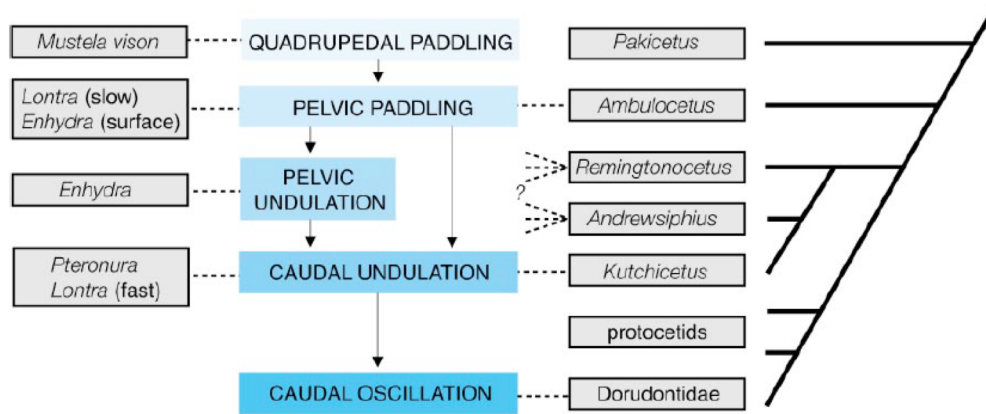
BALEIAS FÓSSEIS ILUSTRAM OS PASSOS EVOLUTIVOS DE UM GRUPO TERRESTRE QUE INVADIU O AMBIENTE AQUÁTICO



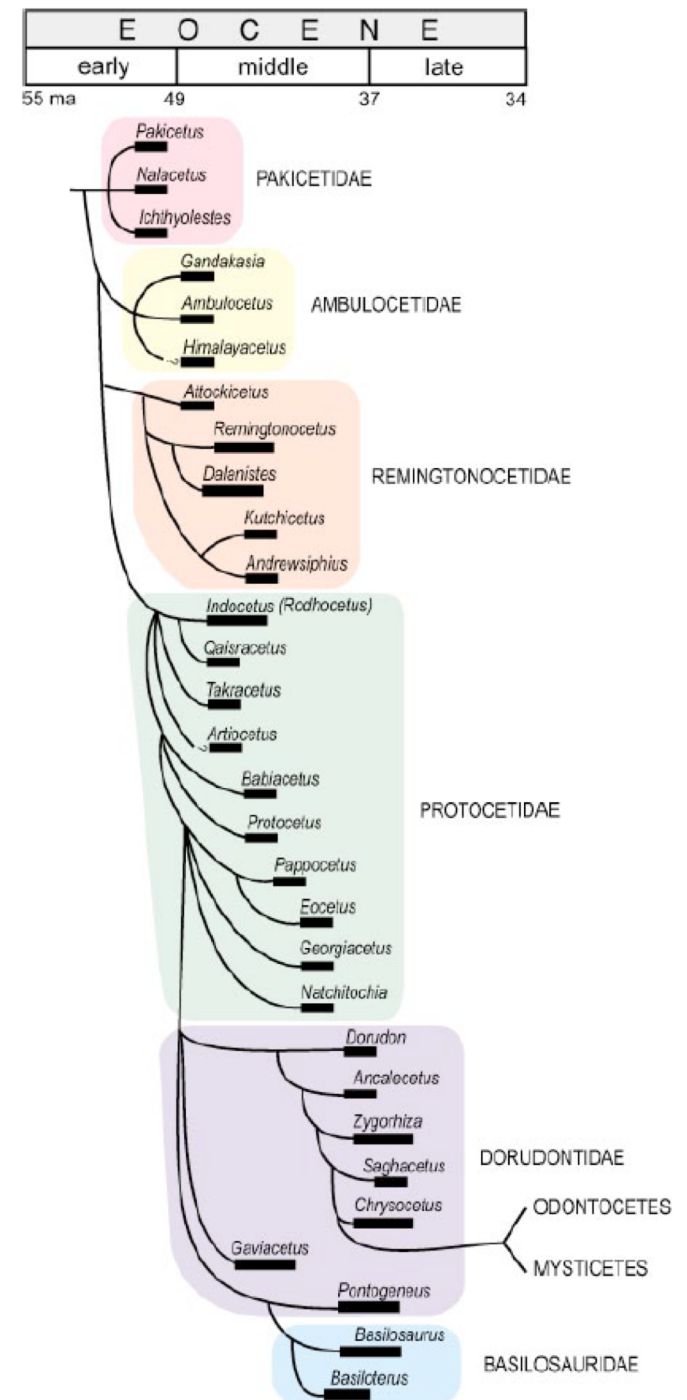
Astragalo de perissodáctilos e baleias primitivas



BALEIAS FÓSSEIS ILUSTRAM OS PASSOS EVOLUTIVOS DE UM GRUPO TERRESTRE QUE INVADIU O AMBIENTE AQUÁTICO



Cetáceos do Eoceno, de cima para baixo em sentido horário: *Dorudon*, *Ambulocetus*, *Pakicetus*, *Kutchicetus*, *Rodhocetus*



FORMA E FUNÇÃO: graviportais (pesados)

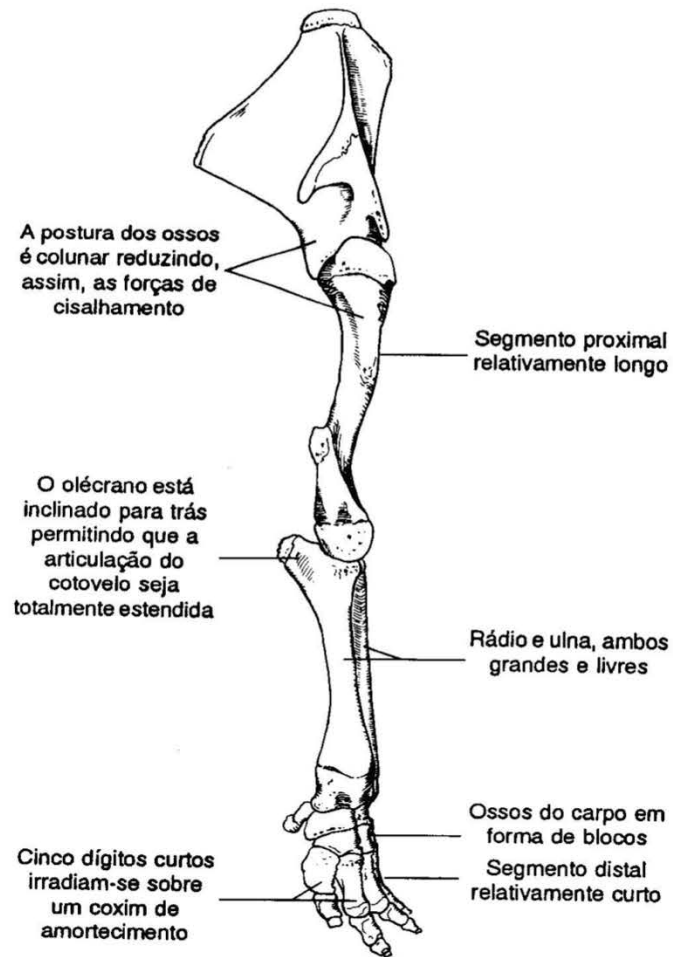
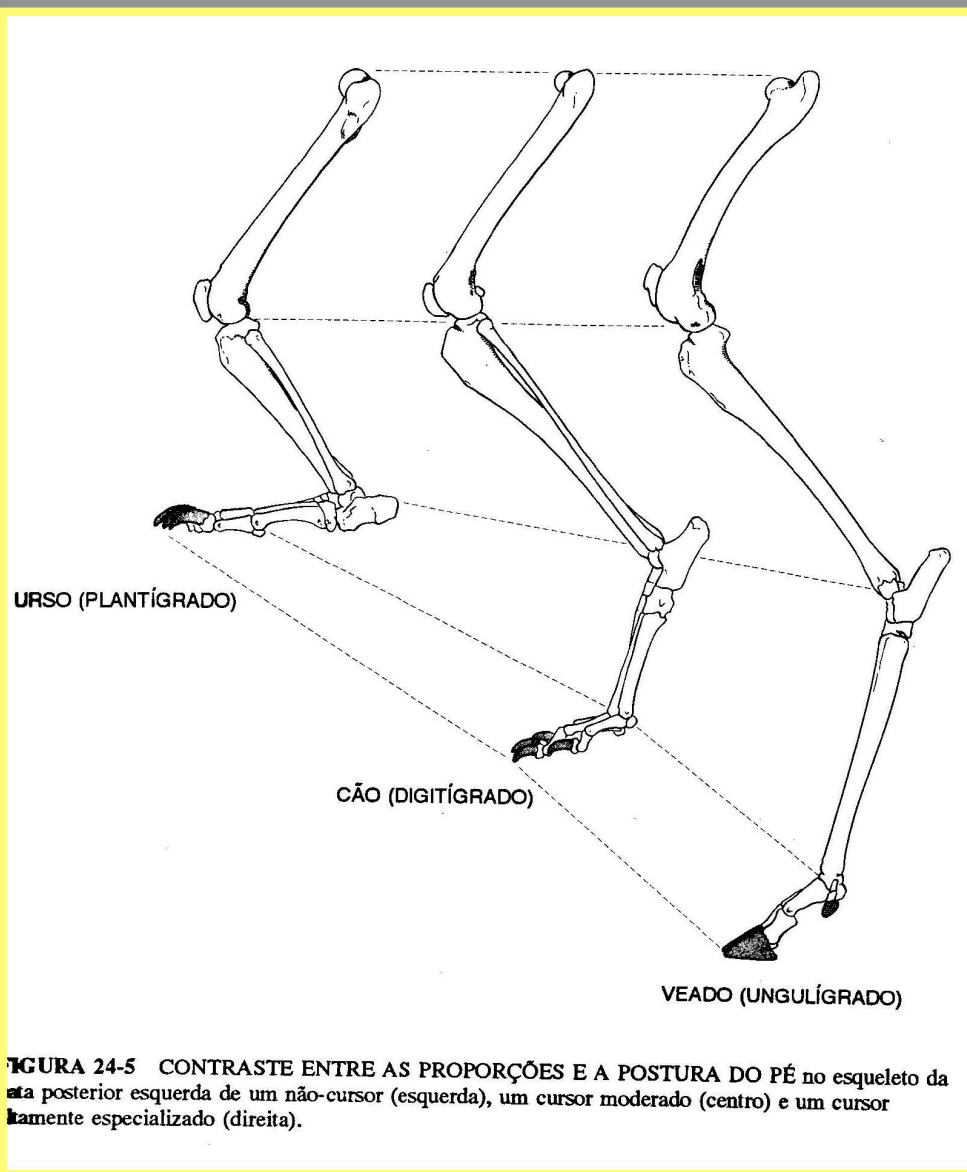
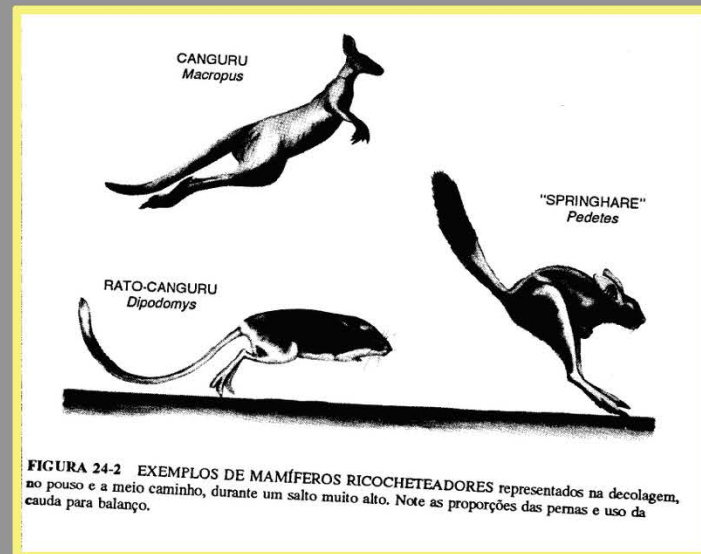
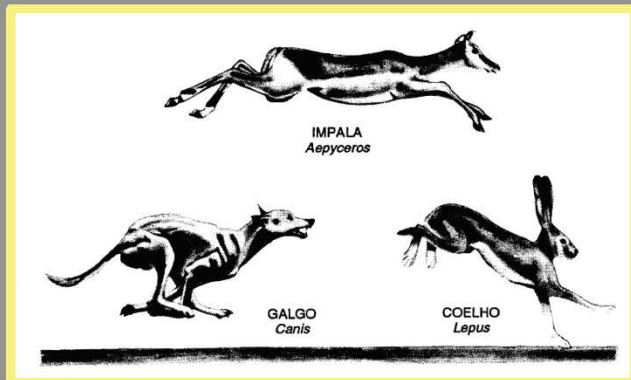
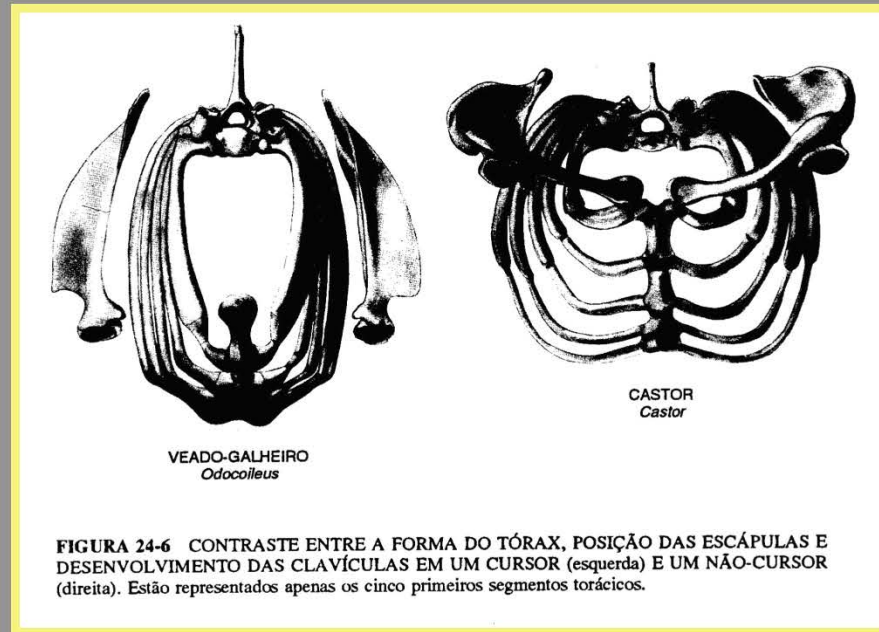


FIGURA 23-4 ALGUMAS ADAPTAÇÕES GRAVIPORTAIS da pata anterior direita de um elefante *indiano*, *Elephas*, de 12 anos de idade.

FORMA E FUNÇÃO: cursores



FORMA E FUNÇÃO: cursores e saltadores



FORMA E FUNÇÃO: escavadores

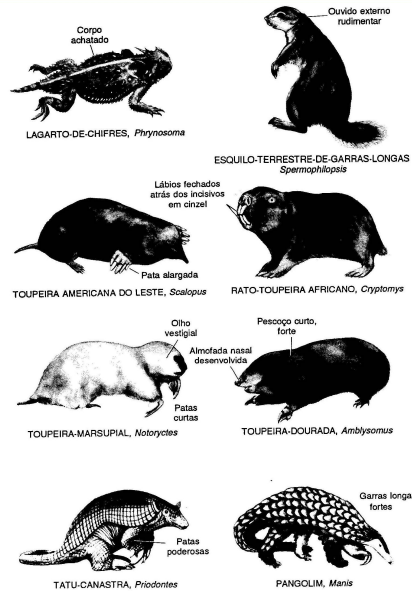


FIGURA 25-2 EXEMPLOS ADICIONAIS DE ESCAVADORES mostrando algumas de suas adaptações.

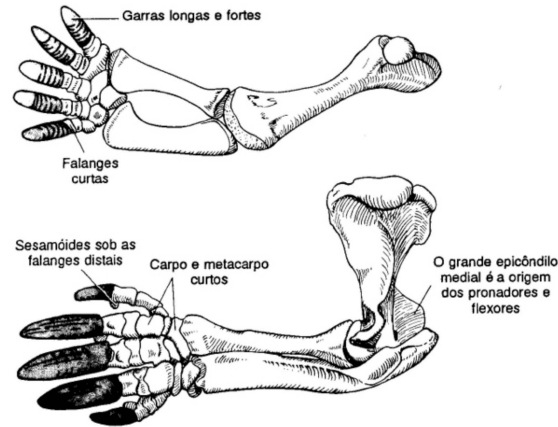


FIGURA 25-5 ALGUMAS ADAPTAÇÕES PARA A ESCAVAÇÃO ilustradas por vistas dorso-laterais do esqueleto da pata anterior esquerda do jabuti, *Gopherus* (acima), e da eqüidna, *Tachyglossus* (abaixo).

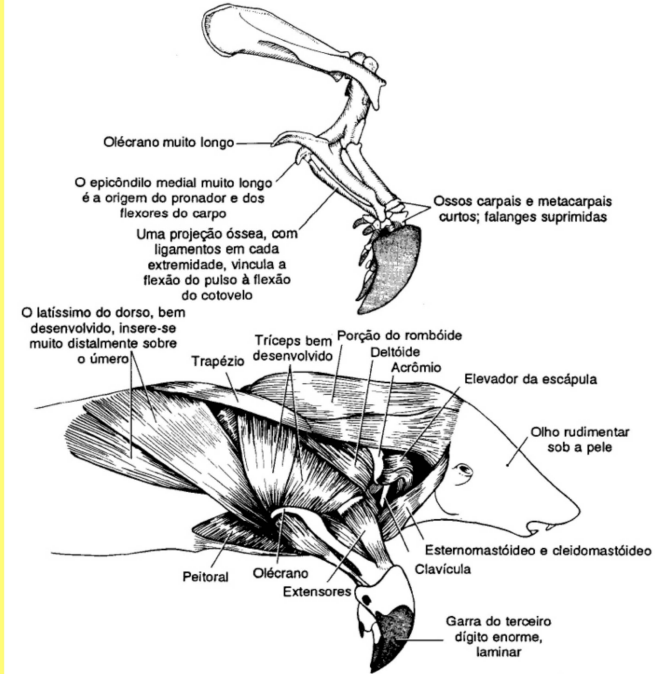
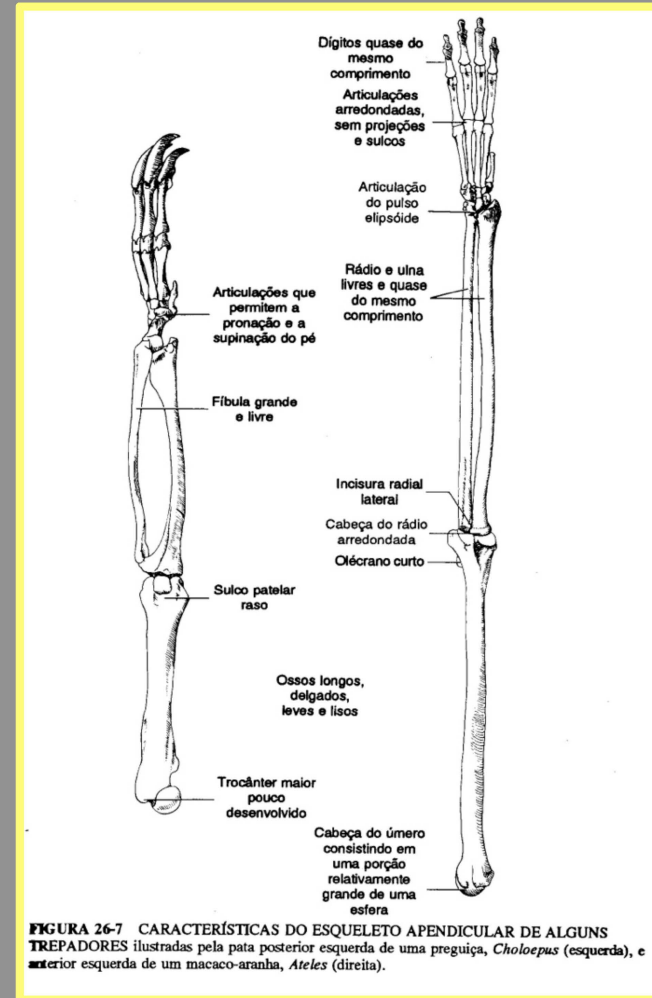
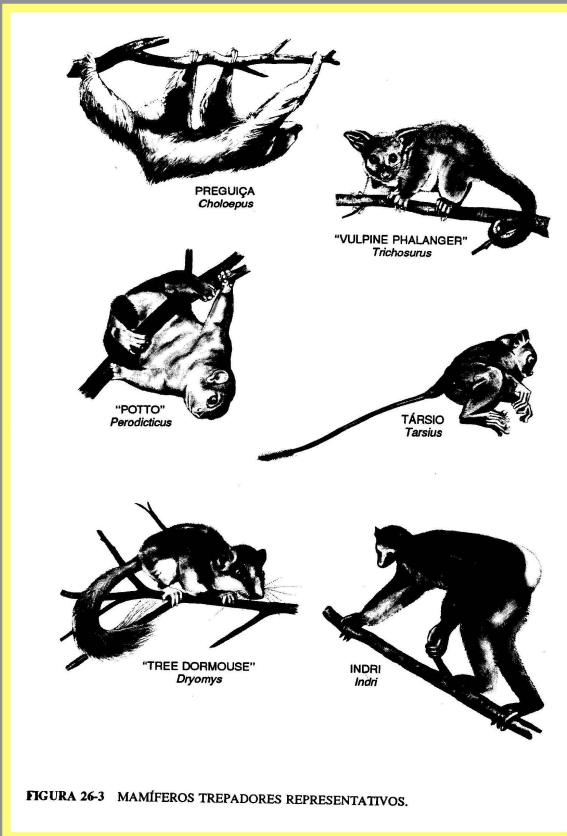


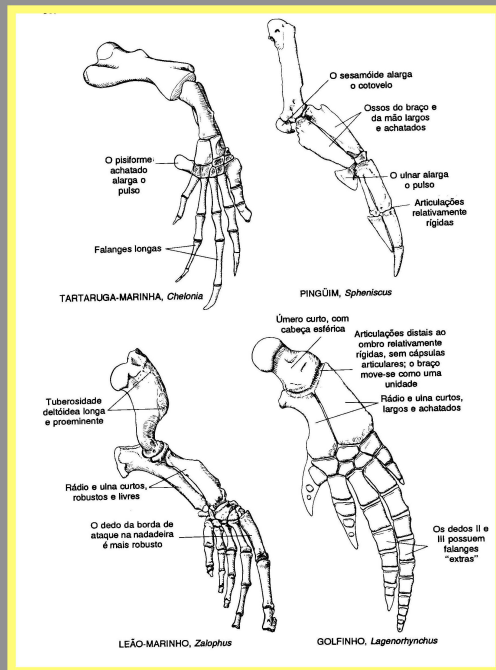
FIGURA 25-7 ESTRUTURA ASSOCIADA À ESCAVAÇÃO POR RASPAGEM NA TOUPEIRA-DOURADA, *Amblysomus*.

FORMA E FUNÇÃO: trepadores



FORMA E FUNÇÃO

nadadores



voadores

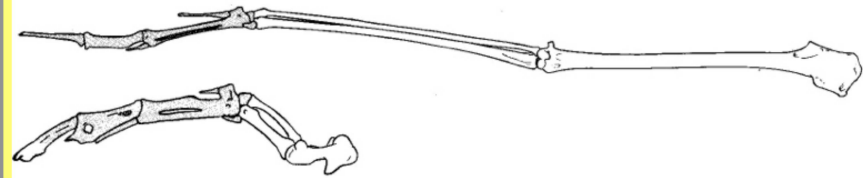


FIGURA 28-15 CONTRASTE ENTRE OS ESQUELETOS DA ASA ESQUERDA DE UMA AVE DE PLANEIO DINÂMICO E DE UMA AVE QUE PAIRA, exemplificadas por um albatroz, *Diomedea* (acima) e um beija-flor, *Lampornis* (abaixo). O esqueleto das mãos foi desenhado com o mesmo comprimento.

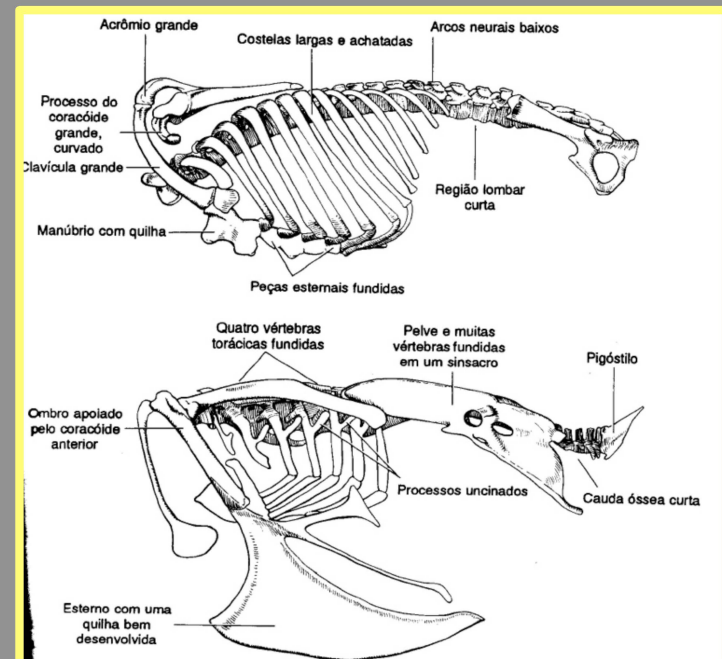


FIGURA 28-16 ALGUMAS CARACTERÍSTICAS DO ESQUELETO DO CORPO DE VERTEBRADOS VOADORES, exemplificados por um morcego, *Pteropus* (acima), e por um faisão, *Meleagris* (abaixo).